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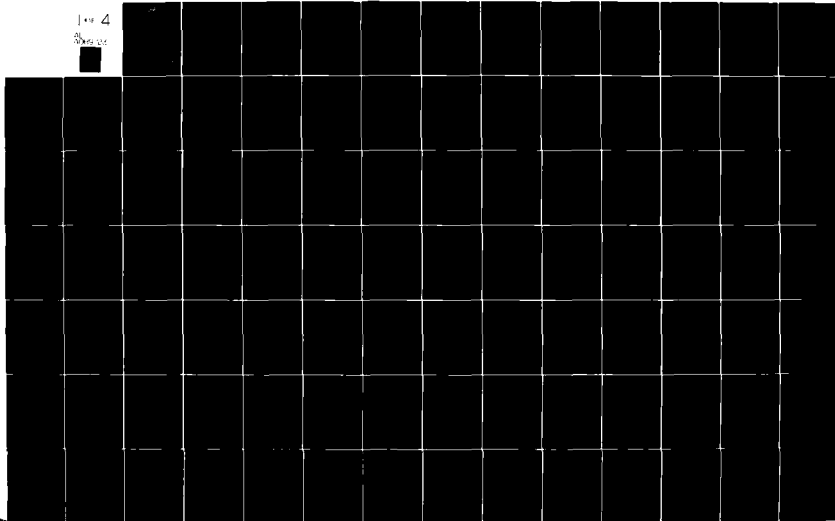
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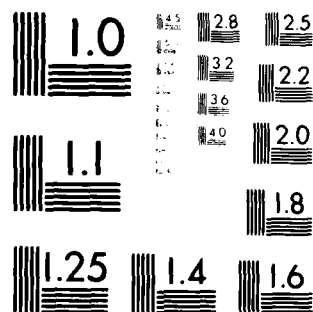
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## DEVELOPMENT AND IMPLEMENTATION OF TCOR COMMO

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28 February 1980

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| 22. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>An existing tactical combat digital computer simulation model was modified and enhanced to more fully explore the role of tactical communications on the modern battlefield. Some of those modifications and enhancements included detailed representation of the communications system and equipments in that discrete weapons effects (both conventional and nuclear) could be assessed against them. Following development of the prototype capability, four experiments with the |   |   |

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20. ABSTRACT (Continued)

model were conducted to characterize the performance of communications in terms of the outcome of the battle. The first two of these cases were strictly conventional warfare while the second two cases included the employment of tactical nuclear weapons. In each pair of cases, one run maintained communications operationally perfect (impervious to weapons effects) while the other allowed for battle incurred degradation and losses. Detailed comparisons are made among the cases concluding that communication can indeed be quantified in terms of a force multiplier. Additional model refinement is shown to be necessary, especially in the area of automated command, control, and intelligence processing.

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## SECTION 1

### EXECUTIVE SUMMARY

#### 1.1 DNA-TCOR OVERVIEW

The DNA-TCOR model represents an important step in meeting the needs for a mixed, conventional-nuclear, theater level, combat-arms model to examine the issues of modern conflict. The uniqueness of the interactions represented and the complexity of the conditions analyzed are a major advance in combat modeling. TCOR achieved this by discretely characterizing the battlefield and the combatants, and allowing analysis of modern ground combat maneuvers in a highly mobile war. The model features mixed event scheduling and time stepping, variable time steps, mixed Monte Carlo and expected value techniques, and automated decision making and planning at several levels of detail. The model is highly efficient; it is easy to use and modify due to the modular, top-down structured programming techniques used for code generation.

TCOR has a distinct separation of the mental and physical processes. Units which are able to issue orders to other units are called "players." Units that have a physical location are called "pseudo-players." A battalion, which commands companies, the lowest level unit in this study, is a player. Its headquarters company and each of the companies in the battalion are pseudo-players. Physical actions affect pseudo-players. The group of TCOR modules that model physical actions are called the of Combat Interaction and Communications (CIC) set. Purely mental actions are modeled by the Command, Control, and Information (C<sup>2</sup>I) set of modules. The C<sup>2</sup>I set processes only the players. Figure 1 depicts schematically the overall simulation concept.

In TCOR, the modules do not pass information to each other. All communications is through the Simulation Control Software (SCS). Events are scheduled to begin happening at some future point. The details of this go on a future event list (FEL) and on the discrete event list (DEL). A module called SELECT takes the event off the DEL and determines which module should be engaged to work the event.

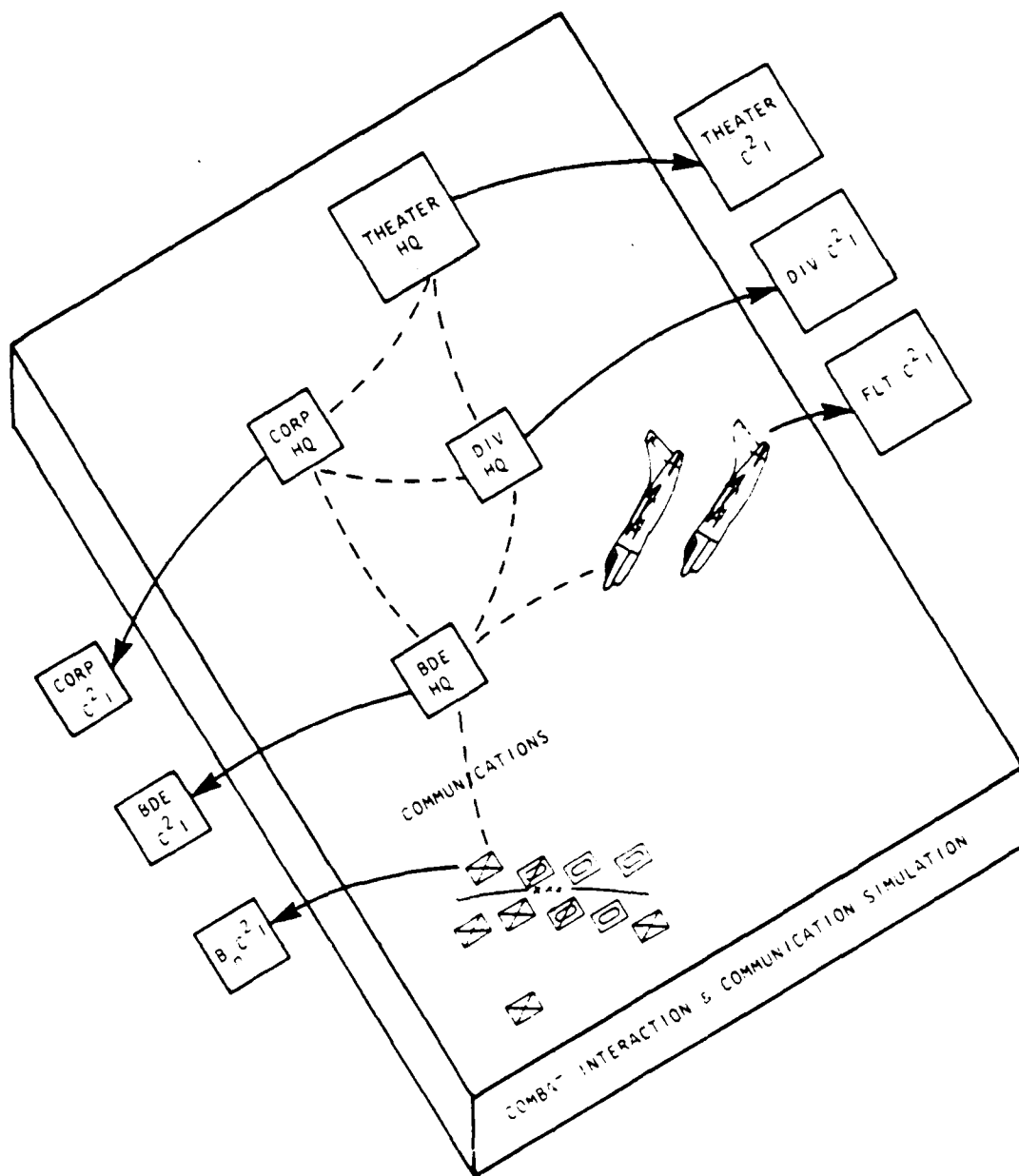


Figure 1. C<sup>2</sup>I/CIC concept.

A key feature of the C<sup>2</sup>I/CIC concept is the inclusion of the human player. This feature permits the Man-in-the-Loop (MITL) to enter the C<sup>2</sup>I process and introduce new OPORDs to the units.

## 1.2 TRACE ENHANCEMENTS

As the acronym TRACE (TCOR Revised to Assess Communications Effectiveness) implies, the basic DNA-TCOR tactical wargaming model was modified, extended, and enhanced by BDM to form an analysis tool that focuses on the role of tactical communications.

BDM expanded the number of distinct types of messages and their contents was expanded. Figure 2 portrays a BDM-developed detailed message transmission processing module. An associated module permitted radios and their carriers to be attrited like any other resource in the model. (There were no replacements for any resource.) Conventional Pk's were developed and analyzed. Each weighted average Pk was converted to a Pk per unit time to be used in the model. Vehicles containing communications equipment were vulnerable to the extent of this Pk from both indirect and direct fire from the enemy. BDM created a whole new Nuclear Weapons Effects (NWE) module to handle the nuclear effects on the communications equipment. This module consisted of seven new routines that check the nuclear effects against various types of radios and their carriers and shelters.

Probably one of the most important developments was the addition of the post-processing capabilities. Prior to this time, there was little or no analyzable output from the model. Three files were created: a checkpoint file, a communications file, and a status file. The checkpoint file holds data needed to restart the simulation. The communications file holds communications for the MITL. The status file contains selected statistics.

Responses to many stimulæ were added to the C<sup>3</sup> functions of the model. Prior to TRACE improvement, model sensitivity to the battlefield environment was very small and primitive.

## 1.3 CASES EXAMINED

BDM conducted four experiments using the prototype TRACE model; specifically, these cases explored the progress of friendly forces, with

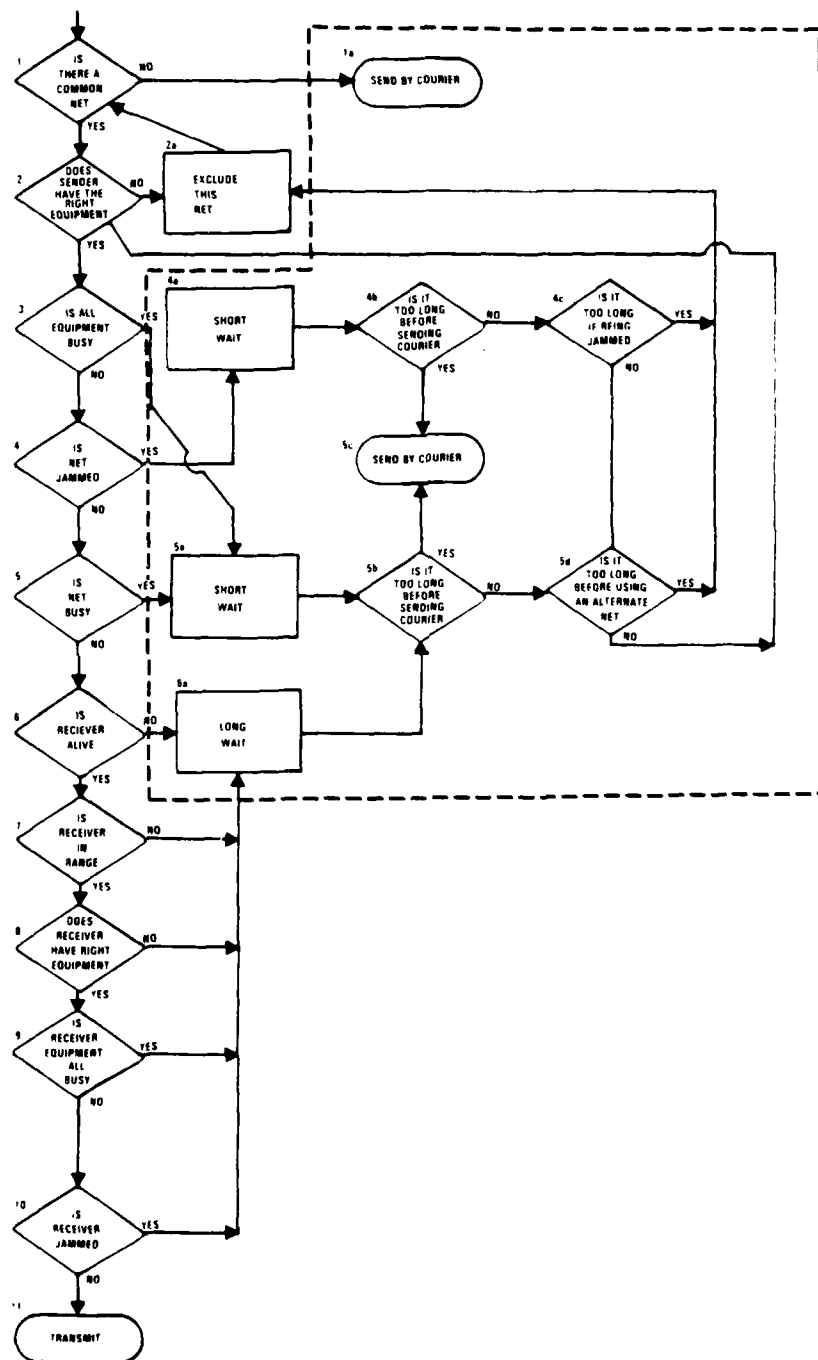


Figure 2. Communications logic flow diagram.

nondegradable and with degradable communications, in a conventional and mixed conventional and nuclear environment. The scenario used in the four experiments represented a Red tank division breaking through a defensive line held by one of the two forward brigades of a Blue armored division. Figure 3 depicts the Red a two echelon attack: a tank and a mechanized regiment followed by two tank regiments. During the conflict a BDM staff member acted as the MITL. He had previous field command experience and was otherwise not associated with the project. Every two hours (by the simulation clock) the TRACE project staff briefed the MITL on the progress of the battle. This briefing was based solely on the communications received at the MITL's headquarters. It was presented in the form of a map overlay showing unit locations. All orders given by the MITL were then injected into the model and another two hours were simulated. During the nuclear cases the MITL had direct control of all friendly nuclear releases.

#### 1.4 RESULTS AND ANALYSIS

The four experiments were numbered in order of production and will be referenced by their number.

- |          |  |
|----------|--|
| Case I   | Conventional War - No communications degradation |
| Case II  | Conventional War - Communications degradable     |
| Case III | Nuclear War - No communications degradation      |
| Case IV  | Nuclear War - Communications degradable          |

There were also two experiments called Case III-FP and Case IV-FP. The FP stands for "free play." In these cases, there was no MITL nor any human intervention. At first these cases were intended as a checkout of the model. However, the results were sufficiently interesting to include for comparison with the cases involving the MITL. The drawdown of combat resources was analyzed extensively. The expenditure of ammunition by supporting forces were linked directly to communications performance. Loss exchange ratios were developed for all six cases in the form of Red unit loss per Blue unit loss. Cases I and II, III and IV, and III-FP and IV-FP were then compared against each other and the results normalized. Figures 4 and 5 show the results graphically at the 5½ and 8½ hour point in



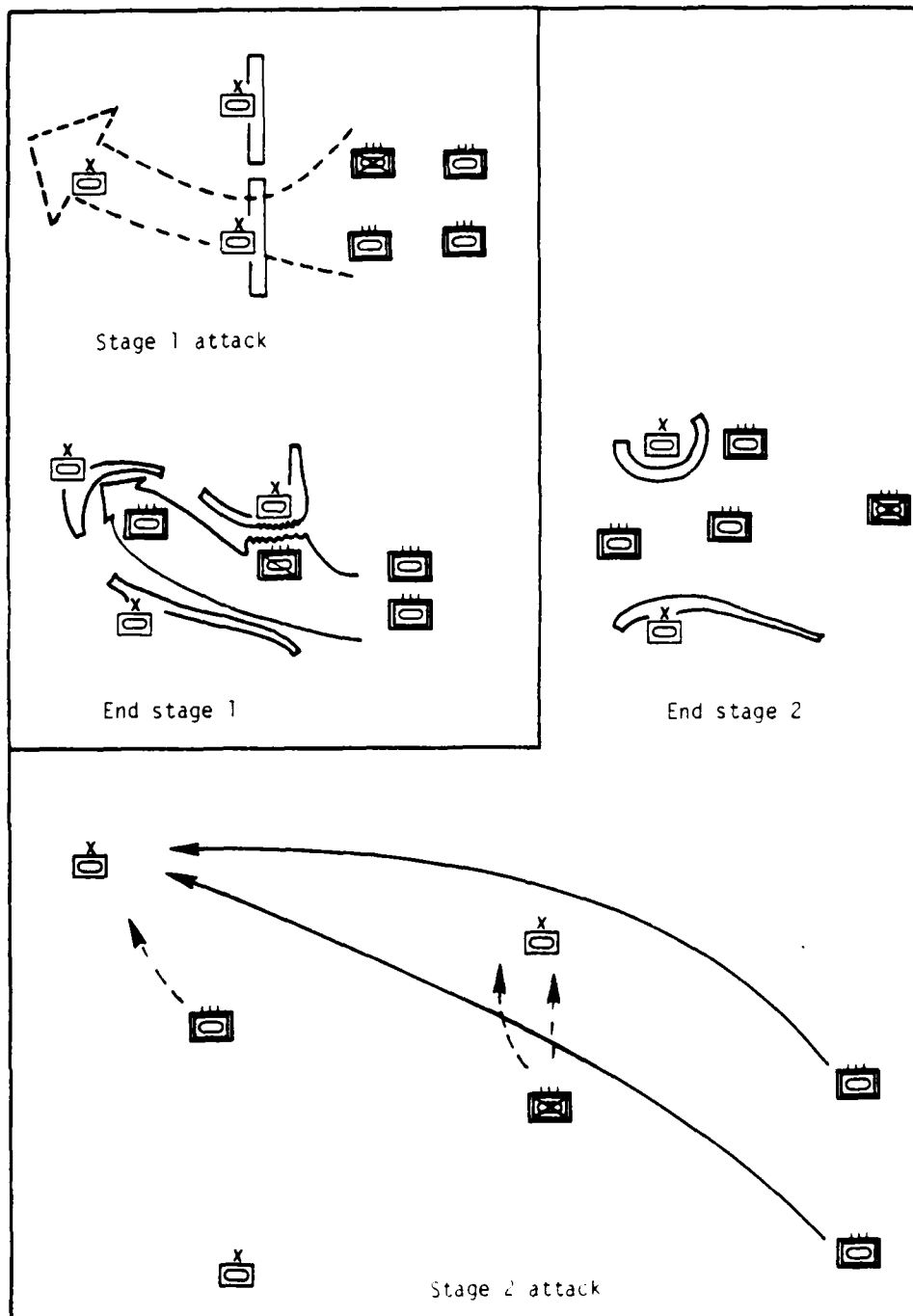


Figure 3. Red two echelon attack.

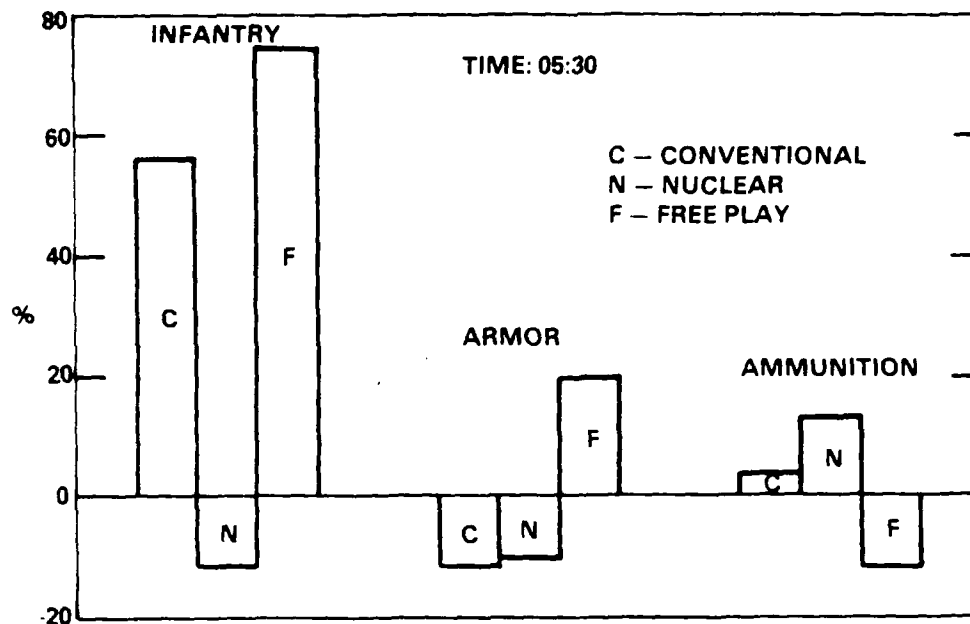


Figure 4. Degraded and non-degraded communications loss exchange ratio comparisons at 0530.

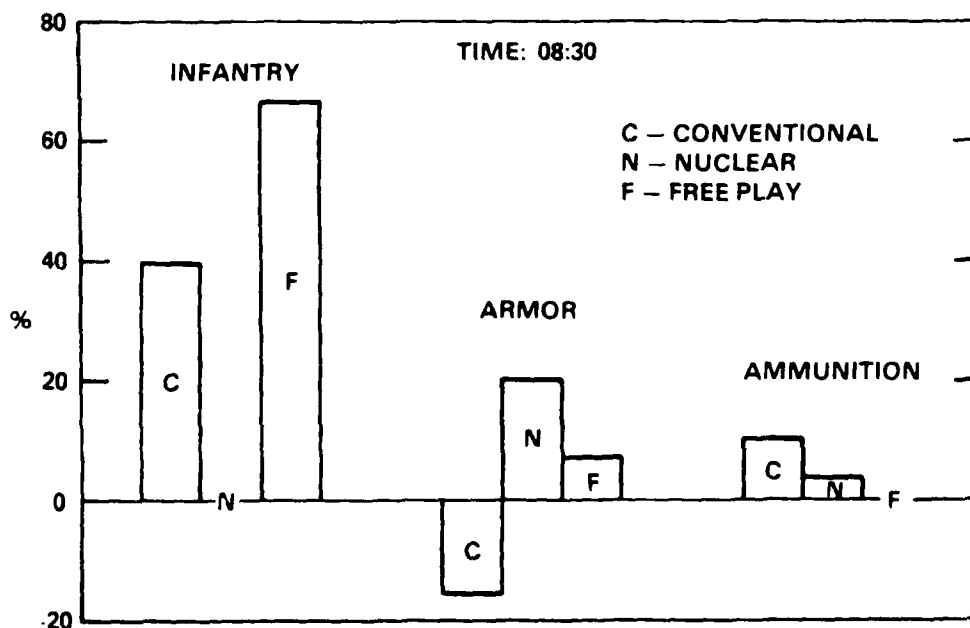


Figure 5. Degraded and non-degraded communications loss exchange ratio comparisons at 0830.

the conflict. A consistent technique for measuring ground loss was developed and applied against the maps generated by the TRACE post-processor. Combining this ground lost with the combat resources lost by both sides, a payoff parameter (P) was developed for Blue.

$$P = \frac{(\text{Red resources lost})}{(\text{Blue resources lost}) (\text{Blue ground lost})}$$

Comparing the cases in the same fashion as before, P (nondegradable communications) is shown in Table 1.

Table 1. Case payoff parameters and comparisons

| CASE   | PAYOFF | RATIO |
|--------|--------|-------|
| I      | .0152  | 1.103 |
| II     | .0138  |       |
| III    | .0165  | .732  |
| IV     | .0225  |       |
| III-FP | .0160  | 1.341 |
| IV-FP  | .0120  |       |

## 1.5 CONCLUSIONS AND RECOMMENDATIONS

This study began with the hypothesis that communications aids performance on the battlefield. The results did not prove this in a statistically significant manner. In a subjective sense, it could be seen that the communications did aid the MITL in conducting the battle. The main difficulty in proving the initial hypothesis was the lack of statistical confidence in the results generated by the set of cases run. This study has shown that improved communications has a measurable effect on the progress of the battle and the C<sup>2</sup> capabilities of the commanders. The study gave evidence that good communications acts as a force multiplier but was not able to measure this multiplier. It did point out the interfering

conditions and the path to parameterizing most of them. Hence, this type of analysis shows promise for isolating and measuring the force multiplier. Further study may now follow two different directions. Although seemingly in the opposite directions, they are not mutually exclusive and should be considered together.

The first direction is a proper simulation study totally excluding human induced variance. This requires that the  $C^3I$  functions be automated totally. It also requires acceptance of the belief that artificial intelligence (AI) can reasonably reproduce the  $C^2$  thought processes. Once a suitable  $C^2$  AI system is placed into a model like TRACE, autoregressive analysis can be used over a number of sets at similar cases where each set has a number of runs in it sufficient for statistically sound results. Degradation of communications could then be quantified and tests made to determine the distribution of the communications force multiplier.

The second direction is the gaming approach. This approach does not require belief in the ability of AI techniques. A group of MITLs is assembled and trained. Each MITL participates in about 30 cases -- sufficient number to make small samples techniques applicable. Mean results can be determined across a MITL's group of cases. By an extension of the Central Limit Theorem, it is known that these means are normally distributed. This facilitates meaningful statistical analysis of the crosscorrelations of the degradation parametric variations in a commander's ability to perform his function. In this way, the force multipliers can be indirectly measured.

## SECTION 2

### DNA-TCOR OVERVIEW

#### 2.1 INTRODUCTION

The DNA-TCOR model represents an important step toward meeting the need for a mixed, conventional-nuclear theater level combat-arms model to examine the issues of modern conflict. The uniqueness of the interactions that had to be represented and the complexity of conditions to be analyzed required a major advance in combat modeling. TCOR achieves that goal by characterizing the battlefield and the combatants discretely, allowing analysis of modern ground combat maneuvers and the use of air power in a highly mobile war. The model features mixed event and time stepping, variable time steps, mixed Monte Carlo/expected value techniques, automated decision making and planning at several levels of detail, and a modular, top-down structured approach to computer code generation. The integration of these techniques has resulted in a model which is efficient, transparent, virtually self-documenting and easy to use and modify.

##### 2.1.1 Concept for Separating Mental and Physical Processes

The actions of all modeled units, including the command elements, are processed by two different sets of modules depending on the nature of the actions. If the unit actions are physical, such as moving, acquiring targets, or firing, they are modeled within the Combat Interaction and Communication (CIC) set. Any action that is purely mental and occurs within the unit or command element is processed by models within the Command, Control, Information (C<sup>2</sup>I) set. Together, these two sets are referred to as the C<sup>2</sup>I/CIC concept.

Since all of the command elements and the communications networks physically exist on the tactical battlefield, they are represented in the combat interaction simulation as shown in Figure 6. All units with command level responsibilities are considered to be "players." Within the corps area, the battalions are the lowest level players, having command of the companies. The brigade, division and corps are also treated as players. The lowest level units are "pseudo-players." In this representation, the

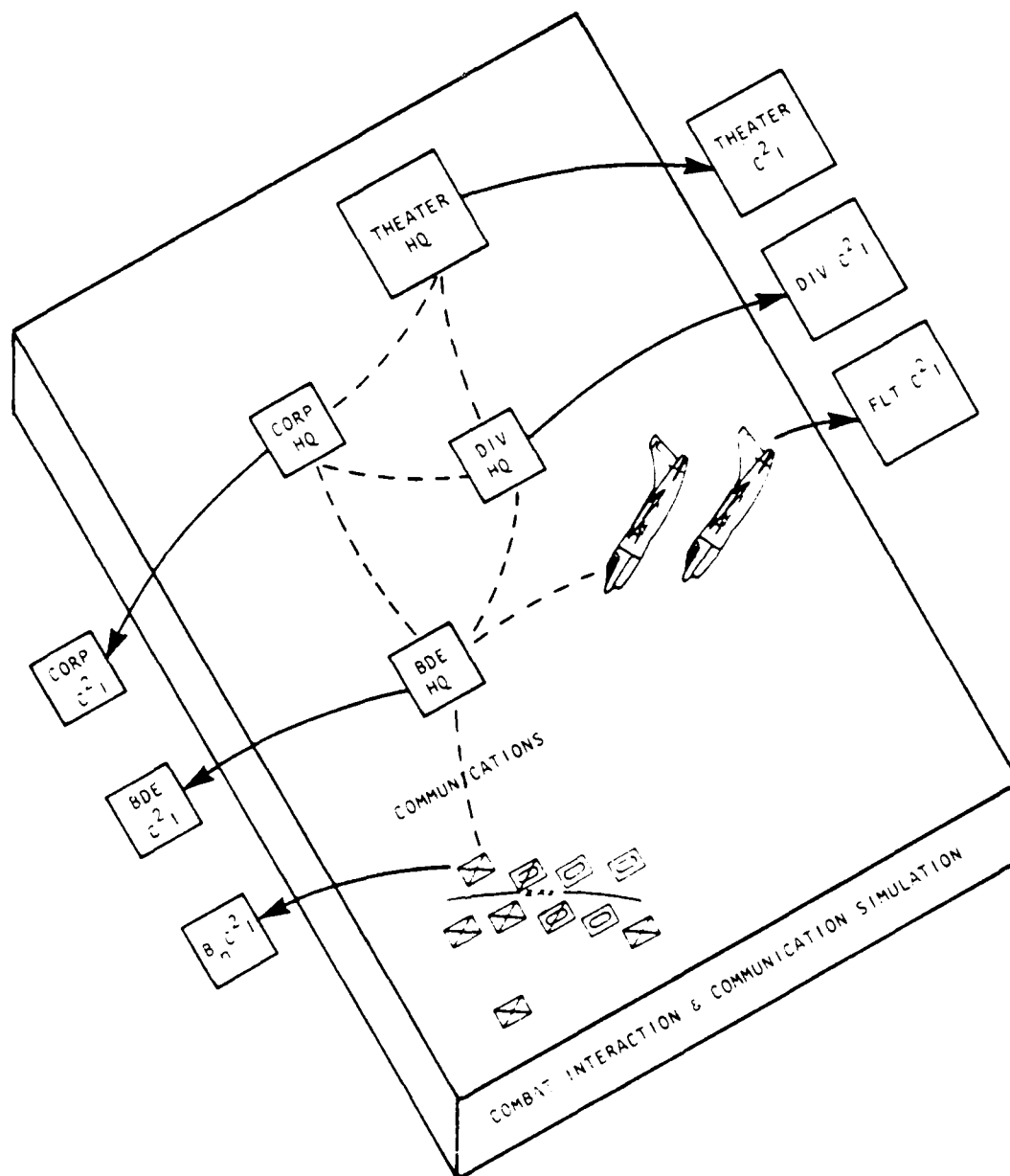


Figure 6.  $C^2I/CIC$  concept.

CIC simulation treats all command units in the same manner as the maneuver and artillery elements are treated. The combat interaction model treats each of the physical actions taken against the pseudo-players. The headquarters units of the players are themselves pseudo-players. In such a configuration, the CIC simulation calculates damage done to the headquarters and the movement of the headquarters when these actions are appropriate. In addition, the CIC simulation models the physical communications network when it is under attack.

When a message reaches a player via an appropriate communications network, the modeling of the mental processes is done in decisionmaking  $C^2I$  modules. The command element's physical activities take place within the CIC simulation, but all modeling of decisionmaking is done in the  $C^2I$  simulation. After a decision is made, the resultant order message is returned to the "physical" commander within the CIC simulation for transmission to other players via the appropriate communications network within the CIC simulation. Basically "players" are  $C^2I$  entities and "pseudo-players" are CIC entities.

The  $C^2I$  processor in TCOR consists of a system of individual models which process the decisionmaking actions of the various players. These modules do not communicate or interface directly with one another but only with the Simulation Control Software (SCS). The CIC is similarly composed of a system of modules, each processing different actions of the various pseudo-players. As in the case of the  $C^2I$  modules, these are written so that they do not communicate with each other but only with SCS.

#### 2.1.2 TCOR Structure

The major functional areas of TCOR are:

- (1) Automated Data Base,
- (2)  $C^2I$ /CIC Process Modules,
- (3) SCS,
- (4) Simulation Data Structure, and
- (5) Man-in-the-Loop (MITL) capability.

The general structure of TCOR, as shown in Figure 7, is described in this section. Each component is described in detail in subsequent sections.

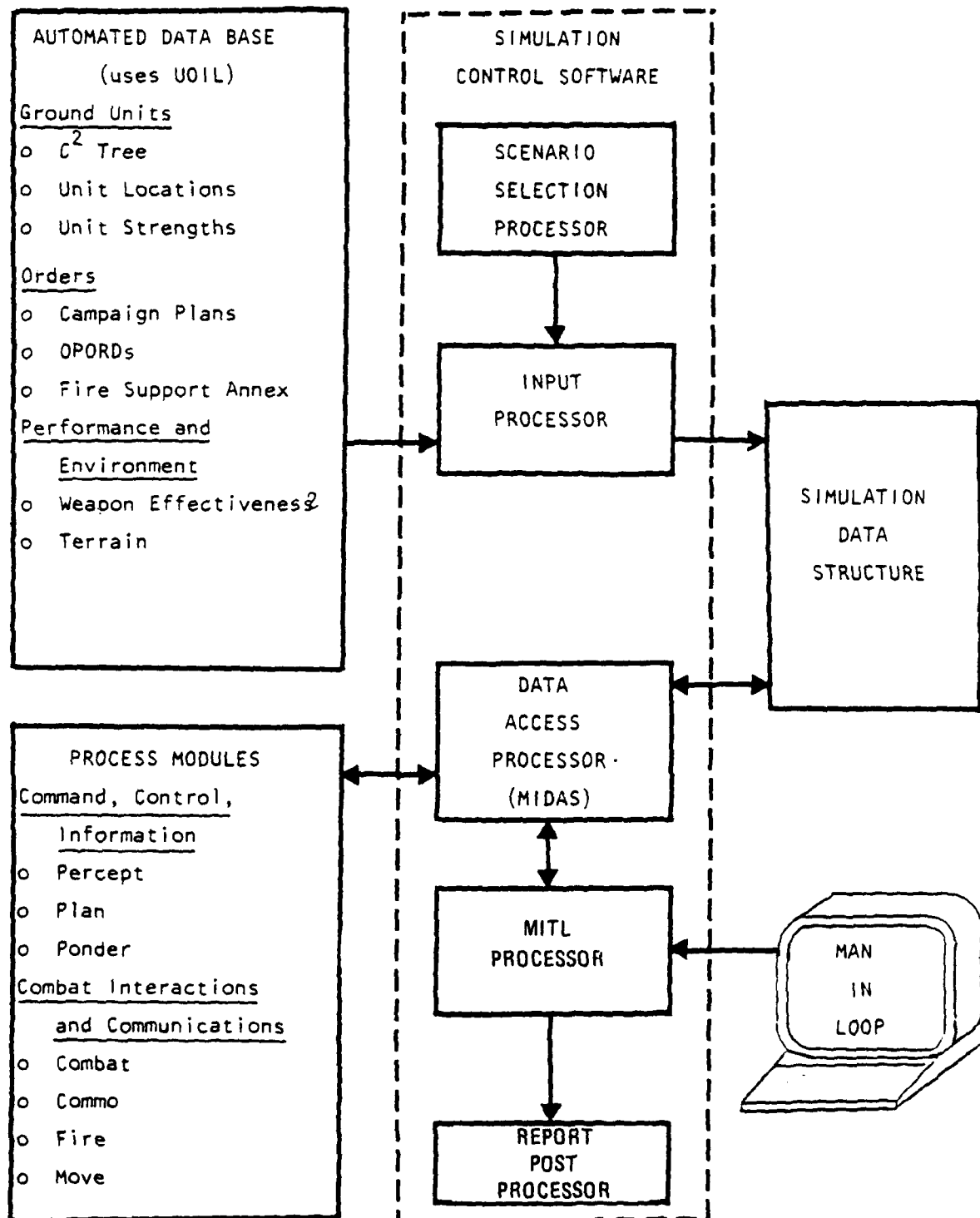


Figure 7. General DNA-TCOR structure.



Input to the TCOR model is achieved by means of a User Oriented Input Language (UOIL) employing subject, verb and object phrases. An example of UOIL appears in Appendix C of this report.

In the UOIL Red and Blue sides are identified by an introduction line followed by the unit identification, unit location and command structure. Other input data, such as terrain and communication network descriptions, are described in a similar form.

The Scenario Selection Processor (SSP) is the interface for the user to initialize the execution of TCOR. The user identifies the data in the Automated Data Base (ADB) that is to be used and specifies any additions or modifications required for the specific scenario. The Input Processor (IP) locates the appropriate data, merges the SSP and ADB information and creates the initial Simulation Data Structure (SDS).

The input data is stored in a dynamically-allocated data space that expands, contracts, and is reused depending on the actual requirements for space during input or execution. This is accomplished by use of list processing techniques and eliminates the requirement to edit and change C<sup>2</sup>I and CIC modules when additional data structures are required. The major data elements are shown in Figure 8.

The scoreboard contains all of the real attributes of each unit in the simulation. The perceptions list contains the unit's understanding of its battle environment. The communications network is characterized by nodes and links. The Discrete Event List (DEL) contains all of the currently scheduled events that are to occur at a future instant in time. This list is sorted by a highly-efficient leftist tree algorithm. The Continuous Event List (CEL) contains all of the currently scheduled events that are to occur during a period of time. The effects of the events on the CEL are calculated for various time intervals. The difference in time intervals and step sizes that are used simultaneously for different events is a power of two greater than the smallest step size allowed in the simulation. The sequencing of the step sizes is accomplished by a highly-efficient binary hierarchical control algorithm. The sequencing of events on the CEL with events on the DEL is accomplished by the CONTROL function in the Module Control Processor (MCP).

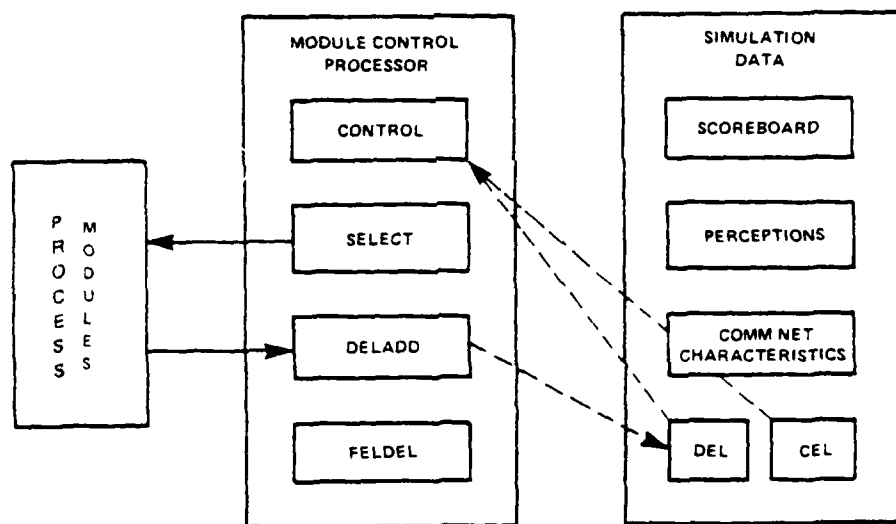


Figure 8. Interactions among major elements of the C<sup>2</sup>I/CIC concept.

SELECT determines which module should process the current event. After the module calculates the effect of the event on the simulation, it may add an event to the DEL via DELADD or delete events from the DEL or CEL using the future event list delete function (FELDEL). All events on the CEL are initialized by an event on the DEL but once an event is on the CEL its time step may be increased or decreased directly.

The simulation is initiated by input of an event or events on the DEL. The event is removed from the DEL by CONTROL and transferred to SELECT to call the appropriate CIC or C<sup>2</sup>I module. The number and complexity of the modules vary widely depending on the degree of detail required and the scope of the simulation. There are sets of modules that differ by combat unit size and functions as depicted in Figure 9. In addition, there are alternative modules that provide for decisions by employing man-in-the-loop techniques. Modules can be mixed as desired in any one simulation. The time at which each event occurs may be stored for post simulation query by a routine named CACHE. This query is done using a post processor and provides the capability to trace the impact of each event on unit status to its source. In addition, combat reports are produced by the Report Processor.

A key feature of the C<sup>2</sup>I/CIC concept using the TCOR structure and software is the capability of introducing a human player into the decision-making processes. This is called the Man-in-the-Loop (MITL). In such a situation, the human would play the role of any or all of the commanders being simulated and "make" the decisions for the model. Whenever human interaction is required the main simulation is halted, the MITL processor is run and human generated orders are entered into the model. The main simulation is then restarted.

In calling a human decision maker, the C<sup>2</sup>I logic would display to the decision maker only that data that exists in the computerized commander's status display board, i.e., his perceptions. This data could be different than the "real" situation, such as being inaccurate, incomplete, distorted, or out of date. It would, however, be the data that the simulation had calculated as available to the human commander and would be the

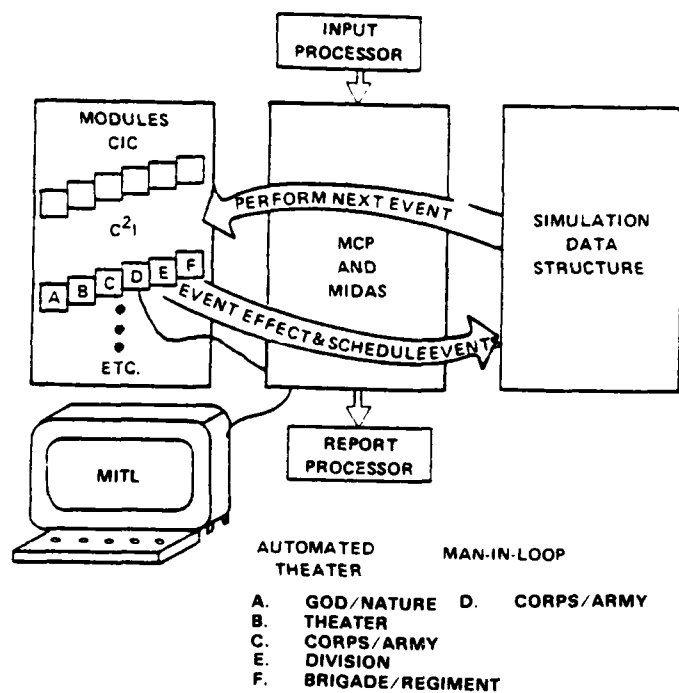


Figure 9. TCOR Modularity

same data available to an automated module. In TCOR II-A, however, perceptions are the same as the "real" situation at the time at which they are perceived. Since the current version of TRACE is derived from the II-A version of TCOR, this is also true for the TRACE model.

## 2.2 SCOPE

TCOR is a symmetric two-sided theater level model, containing two primary levels of detail. One Corps/Army area contains detailed modeling to the battalion level (with company centers), and the other Corps/Army areas are modeled as corps (with division centers). The scope of the automated  $C^2$  in the TCOR II-A version is sufficient to control the interactions involved in force buildup, road march, and the initial phases of meeting engagements and breakthroughs. Opportunistic combat reaction, decision, and movement are accomplished by man-in-the-loop operation.

The basic element in TCOR II-A is a maneuver unit. Input parameters require some level of aggregation of the capabilities of the weapon systems that maneuver units possess. This aggregation process is a function of the assumptions derived from specific combat scenarios.

## 2.3 PROCESS MODULES

The Command, Control, Information ( $C^2I$ ) process modules are PERCEPT, PONDER, and PLAN. The combat Interaction and Communication (CIC) process modules are COMMO, MOVE, COMBAT, and FIRE.

### 2.3.1 Command, Control, Information ( $C^2I$ ).

2.3.1.1 General. Command and control processes represented in all corps areas include plan formulation and selection, resource allocation, targeting, and issuance of directives and orders. TCOR models the command hierarchy and several types of command structures. All commanders at the various echelons are provided with information (via PERCEPT) appropriate for the  $C^2$  processes modeled. Decision making for the theater commanders and the detailed Corps/Army commanders is performed through the man-in-the-loop capability. (Man-in-the-loop capability also provides a research tool for gaining a better understanding of these more complicated decision processes and for developing decision making algorithms for use in later phases of the TCOR development.)  $C^2$  processes below theater (aggregated

areas) and Corps/Army (detailed area) are treated by automated means subject to override via man-in-the-loop capability of the theater and detailed corps commanders. Nuclear release procedures may be directed or automated according to the release permissions in the orders issued by the MITL.

Target acquisition processes are modeled notionally (in PERCEPT) in the aggregated area. In the detailed area, rudimentary representations of sensors are modeled to perceive company/battery centers with no further target discrimination. Target perceptions are treated by rudimentary fusion processes to provide targeting information.

2.3.1.2 Modules. The PERCEPT module encompasses all processes related to incoming stimuli or information. The PERCEPT module also assimilates new information into the unit's existing perceptions. All types of acquisition devices such as radars, sensors, visuals, etc., are under the purview of PERCEPT. PERCEPT is event-stepped. In TCOR II-A, units have only one "acquisition device" with one range associated.

The PLAN module contains logic to develop rudimentary OPORDs for subordinates. The OPORDs prescribe objectives, sectors of operation, type of operation, weighting factors for movement choices, thresholds for casualty totals, casualty rates and movement rates. Allocation of resources occur under the PLAN module in a very simple routine which considers enemy threat, resources available, and type of operation being carried out (such as attack or defend). The PLAN module interfaces with man-in-the-loop and user input. For example, changes to OPORDs will be through the PLAN module.

The PONDER module is a low level decision making module and chooses a general response to an input stimulus. For example, if an enemy shoots at a unit, the potential victim will decide in PONDER if he wants to shoot back, move, ask for help, or any combination of these. In military terms, the PONDER module acts as the adjutant or S-1; it distributes incoming correspondence to the proper action staff section. This section (for example, operations, intelligence, or supply) will then decide what specifically should be done. The PONDER module uses delay times to account for loading of the system, "thinking and reacting" time, and is event-stepped.

Movement and location of forces is in accordance with the multi-level hexagonal coordinate system developed in TCOR I. Company centers in the detailed corps area are associated with hexagons of 1.35 km diameter (center-to-center). Divisions, in the aggregated corps areas, are located in hexagons of 25 km diameter. Terrain information is treated in terms of trafficability and cover and concealment indices which are stored at the highest level hexagon consistent with terrain variability.

### 2.3.2 Combat Interaction and Communications

2.3.2.1 General. The CIC processes modeled included ground movement, direct fire, indirect fire, tactical air support, and communications. Ground combat is modeled simultaneously at two levels of detail. Within the aggregate Corps/Army areas, the model represents combat between corps and army division centers using notional weapon systems (armor, infantry and artillery) capable of both conventional and nuclear fires. Within the detailed Corps/Army areas, the model represents the operations of maneuver battalions (consisting of company centers) possessing armor and infantry weapon systems and the ability to move and enter combat with opposing forces. In addition, it represents the operations of artillery battalions (consisting of battery centers) equipped with tube artillery of rockets and capable of moving and firing at enemy maneuver, artillery and C<sup>2</sup>I units. Artillery batteries within the battalion are capable of supporting more than one maneuver battalion at a time in accordance with instructions from a fire direction center. The combat effectiveness of a unit is influenced by the effective range and firing rate of its weapon systems and the vulnerability of the enemy weapon systems being fired upon. Weapon systems are described by parameters related to their mobility, reliability, and lethality. The actual employment of weapons systems in an orchestrated combat action is influenced by physical limitations, the plans and order developed or used in the model, and the perceptions of enemy forces present in the area. Attrition is influenced by the cover and concealment index of the target location. Ground mobility is constrained by OPOD input, trafficability, and casualty levels in both area types.

2.3.2.2 Modules. COMMO simulates a generalized communications network linking all units in the chain of command. Specific communications hardware systems are not portrayed. Network performance is represented by a message delay time but point-to-point communication never breaks down completely. The message delay time is random from a Poisson distribution. COMMO is event-stepped.

MOVE provides for non-combatant movement towards an objective that has been directed by an OPORD. The effective movement rate is a function of the trafficability index associated with the unit's location. The choice of direction is a function of the provisions of the OPORD, such as speed range, cover and concealment, massing, and threat constraints. MOVE is event-stepped.

COMBAT calculates the movement of units in combat and the effect of their fire on opposing forces as a function of weapons allocation cover and concealment, force element kill rate (infantry, armor, artillery, CAS), and target composition. COMBAT is time-stepped.

The FIRE module is concerned with indirect fire from artillery battery centers against enemy targets. These can be either maneuver companies, artillery batteries, or command units. Both nuclear and conventional fire may be represented in this module. Firing missions are ordered by the artillery battalion (fire direction center) in response to fire support requests from maneuver units. The duration of a fire mission is calculated using the battery's firing rate. This value is added to the scheduled start time to determine the end of the fire mission. When the end of the firing mission is calculated and event is scheduled to post the attrition results. The FIRE module is event-stepped.

## 2.4 DATA INPUT REQUIREMENTS

Three classes of data are needed to use the TCOR model:

- (1) ground unit descriptions,
- (2) initial OPORDS for the top level ground units in the scenario to be represented, and
- (3) environment and performance parameter values.



All classes of data are normally input by means of the UOIL and thus can readily be varied when desired. The input medium is normally punched cards with a separate card for each item of data that is entered. (Input via CRT is also possible.) Each class of data is discussed in detail below. Examples of UOIL inputs for the pilot runs are exhibited in Appendix C. A rigorous treatment of all data inputs and simulation outputs is available in Reference 2. A higher level synopsis of those inputs is provided in the remainder of this section of facilitate the reader's understanding of the model and its capabilities.

#### 2.4.1 Ground Unit Descriptions

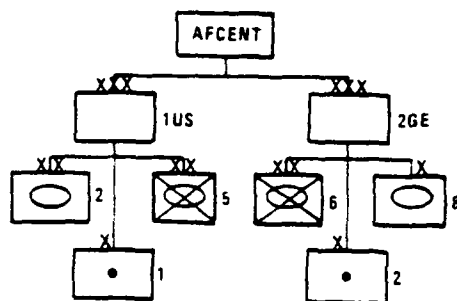
Each ground force unit to be represented in the simulation is defined by three items of information:

- (1) position in the command structure,
- (2) initial location, and
- (3) initial force strength.

Command structure is defined in terms of "the chain of command" starting at Corps (Blue) or Army (Red) headquarters for each side of the conflict scenario to be simulated. In the detailed area only a company or battery level unit can have a physical location and be attacked. Thus, headquarters for higher echelon units are represented as Headquarters Headquarters Company or Battery (HHC or HHB). In the aggregated areas, only divisions or independent brigades/regiments can have a physical location. Higher headquarters are represented as "divisions" in the aggregated areas. The number of units immediately subordinate to a given command echelon can be considered to be unlimited for any scenario that can be foreseen at present. Figure 10 illustrates how a command structure for a hypothetical theater would be represented in UOIL. Although this example treats only the aggregated areas, data for the detailed area is in similar form.

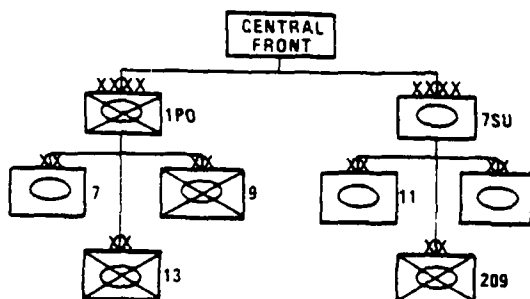
The initial locations of each of the units to be represented can be input by hex number, or latitude-longitude coordinates. This is done by means of a separate card which contains the unit number followed by the statement "is at xxxxxxxx (coordinates)." For the example in Figure 5, a

# LOIL INPUT CARDS



BLUE DEFINITIONS  
 CORPSHQ - CORPS HEADQUARTERS  
 ARMDIV - ARMORED DIVISION  
 MECHDIV - MECHANIZED INFANTRY DIVISION  
 ARTYGRP - ARTILLERY GROUP  
 ARMBDE - ARMORED BRIGADE

BLUE. (1)  
 US. (UNITED STATES) (2)  
 1 AGCORPS COMMANDS 1 AGCORPSHQ. (3)  
 1 AGCORPS COMMANDS 5 AGARMDIV. (4)  
 1 AGCORPS COMMANDS 2 AGMECHDIV. (5)  
 1 AGCORPS COMMANDS 1 AGCORPSARTYGRP. (6)  
 GE. (GERMANY) (7)  
 2 AGCORPS COMMANDS 2 AGCORPSHQ. (8)  
 2 AGCORPS COMMANDS 6 AGMECHDIV. (9)  
 2 AGCORPS COMMANDS 8 AGARMBDE. (10)  
 2 AGCORPS COMMANDS 2 AGCORPSARTYGRP. (11)



RED DEFINITIONS  
 TKDIV - TANK DIVISION  
 MRDIV - MECHANIZED RIFLE DIVISION  
 TKAHQ - TANK ARMY HEADQUARTERS  
 CAHQ - COMBINED ARMS ARMY HEADQUARTERS

NOTE: PREFIX AG INDICATES UNIT IS  
 IN AGGREGATED AREA IN THE MODEL.

RED. (12)  
 PO. (POLAND) (13)  
 1 AGCAA COMMANDS 1 AGCAHQ. (14)  
 1 AGCAA COMMANDS 7 AGTKDIV. (15)  
 1 AGCAA COMMANDS 9 AGMRDIV. (16)  
 1 AGCAA COMMANDS 13 AGMRDIV. (17)  
 SU. (SOVIET UNION) (18)  
 7 AGTKA COMMANDS 7 AGTKAHQ. (19)  
 7 AGTKA COMMANDS 11 AGTKDIV. (20)  
 7 AGTKA COMMANDS 17AGTRDIV. (21)  
 7 AGTKA COMMANDS 209 AGMRDIV. (22)

Figure 10. Hypothetical command structure.

companion location card would be prepared for each command structure card except numbers 1, 2, 7, 12, 13, and 18.

The TCOR Model represents the strengths of ground force units in terms of the numbers of four generic types of weapon systems. They may have armor (main battle tanks), infantry units and anti-tank units (light tanks, anti-tank guns and anti-tank guided weapons), artillery tubes, (guns, howitzers, and multiple rocket launchers), and rockets (guided surface-to-surface missiles such as Lance and Scud) assigned to Corps/Armies. Theater-level missiles such as Pershing and Scaleboard are not explicitly included). Note that infantry units and antitank units are treated the same. Thus, they will be referred to by either or both names.

The effectiveness of the generic types of weapon systems is expressed in terms of kill rates against each of four types of targets. These kill rates are input by means of two 4x4 matrices of shooters and targets--one for each side. Development of these parameter values is discussed in later paragraphs. For now it is sufficient to understand that there is provision for only one value to assess the capability of Blue (Red) tanks to inflict attrition on Red (Blue) tanks in both the detailed and aggregated areas. To account for variation in the effectiveness of different Blue (Red) weapon systems, a standard US and USSR weapon system of each generic type has been selected and the number of other weapon system types that a unit possesses is increased or decreased in proportion to the Effectiveness Ratio (ER) of the specific system to the standard. For example, the standard Blue tank is the US M60A1. a British tank squadron possessing 18 CHIEFTAIN tanks ( $ER=1.1$ ) would be considered to have 20 M60A1 equivalents ( $18 \times 1.1 = 19.8$ ). The numbers of other types of weapons are adjusted similarly. The M113-TOW is the standard anti-tank weapon. For the Red side, the T-62 and Sagger ATGM correspond. Capabilities of artillery tubes are based on a weighted average of the US M109/M110 for Blue and the Soviet 122-MM and 152-MM howitzers for Red. Rockets are based on Lance and Scud, respectively.

In addition to specifying the adjusted number of tanks, ATU, tubes, and rockets that a unit has, it is necessary to specify the number

of rounds of conventional and nuclear munitions. Generally, Blue units are assumed to have their basic loads and Red units their standard unit of fire. For example, a Blue armor company has 62 rounds for each tank and a Red tank company has 40 rounds for each tank.

Unit strengths are input by cards using the following format-- (unit designation) has (xxx) TANKS, (xxx) ATU, (xxx) TUBES, (xxx) ROCKETS, (xxx) ROUNDS, (xxx) GROUNDNUKES. The values attributed to HHC, HHB and AGDIVHQ are a nominal ATU/Tank capability and a nominal amount of ammunition.

#### 2.4.2 Initial Operations Orders

Two sets of OPORDs must be prepared: one each for the detailed Blue corps and Red army commanders. These are quite similar in format and are discussed from the detailed Blue corps standpoint. OPORDs are input to the MITL processor for inclusion in the data base. Part IV, Appendix C shows a complete set of orders, first for Red (2 divisions) then for (Blue). The Blue units are given their movement and loss constraints, told whether or not nuclear fires are permitted and then given their boundaries. After the boundaries come the mission statement (types and time) and the phaselines. Complete details on this are found in reference 2.

#### 2.4.3 Environmental and Performance Parameter Values

Terrain is the only type of environmental data used in TCOR II-A. (Weather and other environmental factors are planned to be added to future versions of TCOR.) Terrain effects are manifested in the model in two ways:

- (1) As trafficability constraints on movement, and
- (2) As cover and concealment constraints on attrition.

These two effects are expressed as indices associated with a particular hex, usually at the 9.45 km hex level. These indices are used in the MOVE and COMBAT modules, respectively, to modify the rate and direction of movement and unit attrition. (No detailed terrain was used in the TRACE study.)

#### 2.4.4 Weapon Effectiveness

Weapon system performance is expressed in terms of kill rates as described above and illustrated in Figure 11. The corresponding Red matrix is of similar form.

|         | TANKS | ATU   | TUBES | ROCKETS |
|---------|-------|-------|-------|---------|
| TANKS   | .0165 | .0097 | .0001 | .0001   |
| ATU     | .0026 | .0030 | .0001 | .0001   |
| TUBES   | .009  | .009  | .002  | .0001   |
| ROCKETS | .35   | .44   | .9    | .49     |

Figure 11. Standard Blue Weapon System Kills of Standard Red Weapon Systems in 64 Sec.

The kill rates in Figure 6 are derived using the relationship:

$$\text{Kill rate} = P_{KIS} \times FR \times TR$$

Where  $P_{KIS}$  = single-shot probability of kill given a shot.

FR = Firing rate or expected number of rounds expended in one time period (64 seconds) against a particular type of target (allocated).

TF = Tactical factor to account for the shooter being suppressed by enemy artillery, and shooting at dead targets.

Although a single value of kill rate is used for both the detailed and aggregated areas this potential disparity is minimized by the specific combat attrition equations used for the aggregated areas. This is done by reducing the number of shooters to represent the condition where all unit weapons are not in range of all targets during a given time period.

#### 2.4.5 Air Operations

The TCOR II-A Model represents air operations in a highly aggregated fashion. There is no detailed modeling of bases or flights. It's

purpose is more to add a communications load and to provide some front line interdiction at the nuisance level. There are no inputs associated with the air operations.

## SECTION 3

### TRACE ENHANCEMENTS

#### 3.1 INTRODUCTION

As the acronym TRACE indicates, (TCOR Revised to Assess Communications Effectiveness), the basic DNA-TCOR tactical wargaming model has been appropriately modified, extended, and enhanced resulting in a analysis tool that focuses on the role of tactical communications.

#### 3.2 COMMUNICATIONS

##### 3.2.1 Messages

There are five types of messages represented in the TRACE model.

They are:

- (1) combat orders (OPORDS),
- (2) status reports (SITREPS),
- (3) artillery fire requests,
- (4) close air support requests, and
- (5) intelligence reports of observed enemy units.

Only player units send and receive messages. Players may send and receive messages on behalf of a pseudoplayer, as discussed in the next paragraph.

##### 3.2.2 Message Simulation

There are a number and variety of stimuli that can generate messages in the five message type categories.

3.2.2.1 Orders. When a Man-In-The-Loop (MITL) enters orders for a unit, if it has any player subordinates, it generated an orders message for each one of the player subordinates. Each of these in turn will send an orders message to it's player subordinates and so on until all players under the one receiving MITL orders have received an orders message.

3.2.2.2 Status Reports. There are three subtypes of status reports. The first is the "reached objective". This is sent by every pseudo-player, through its commanding player, to the next higher level. It is sent when ever a pseudoplayer has reached its current objective. The second type is the "killed in action". This type is sent whenever a unit notices a

neighboring unit being destroyed. A neighboring unit is one in the same or adjacent, level 3 hex. The last type is the "general" status report. This message is sent, with a probability, every time a move event is executed. Certain combat events will also, on a probability, cause one to be sent.

3.2.2.3 Request for Artillery Fire. Artillery fire may be requested at a particular unit/hex whenever a moving enemy unit is identified, an enemy unit using direct fire is identified, an enemy transmitting unit is detected, or an enemy unit is in direct fire range of a friendly unit in combat. Each of these cases has a probability of request associated with it. In the last case only, the single most threatening enemy unit of those within range of each pseudo player will have fire requested against it. For RED only, they may make two requests in this last case due to the policies of greater employment of artillery.

3.2.2.4 Request for Close Air Support. Blue units in combat, in addition to requesting artillery against the most threatening enemy unit, may, with a lower probability, also request a CAS attack against the same unit. (This represents the assumption that Blue will have local air superiority.)

3.2.2.5 Intelligence Reports. These reports are sent on a probabilistic basis whenever an enemy unit is identified while moving or in direct fire combat.

### 3.2.3 Message Processing

When a unit decides to send a message it schedules the first message transmission attempt to happen at zero or more minutes later. This time represents the message preparation time. When the scheduled time comes up the player sending the message attempts to transmit the message. It is at this point that TRACE becomes vastly different, communications-wise, from all other members of the METRIC family of models.

3.2.3.1 Establishment of Communications. The sender must first establish communications with the receiver. Figure 12 illustrates the steps taken to accomplish this or to determine that it can't be accomplished. The numbers in parentheses in the text below reference points on the flow chart.



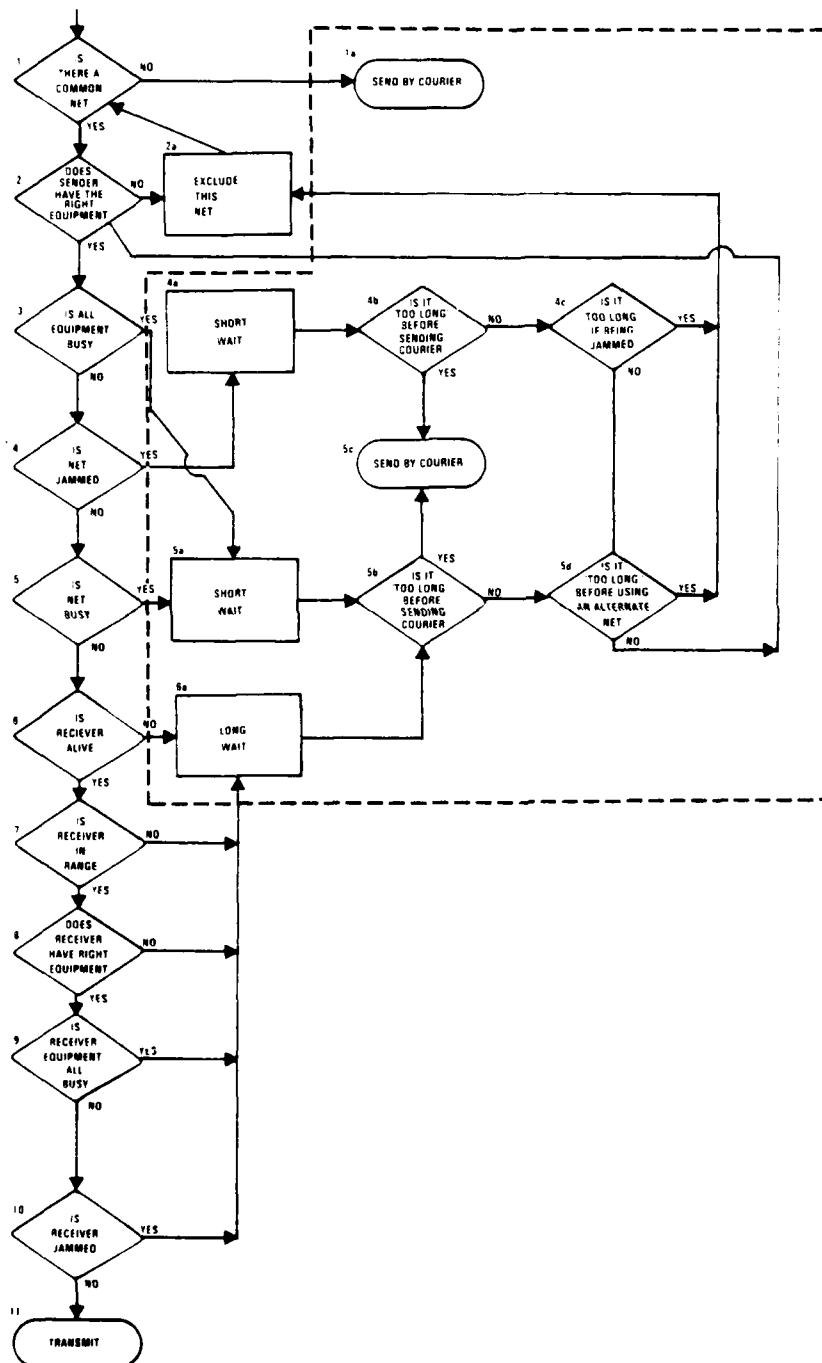


Figure 12. Communications logic flow diagram.

4  
The sender checks (1) to see if the receiver is on any net that the sender is authorized to transmit over. The first net he checks for is the one appropriate to the message type. If there is none the sender must courier (1a) the message. If the sender does have a net, he determines (2) whether he has any equipment that covers the frequency of the net. If not (2a) another net must be chosen.

Given a net and the proper equipment, the equipment is checked (3) to see if it is all in use at this time. When all equipment is busy a short time delay (5a) is involved. This delay includes the checking of all the equipment and the possibility of a short wait to determine if any will soon be freed up. After this short wait, the time span since message origination is checked. If more time has passed than permissible for transmission attempts (5b), the message is sent (5c) by courier. If more time has passed than permissible before trying a secondary net (5d) then another net must be chosen (2a).

Should some equipment not be busy, the sender now listens with it. If he is being jammed (4) a similar procedure (4a, 4b, 5c, 4c) takes place to that had the equipment been busy (5a, 5b, 5c, 5d).

Even if not jammed, the net may already be busy with traffic (5). When it is, the exact same procedure is followed as if the equipment had been busy (5a, 5b, 5c, 5d). There are two ways that the net can be busy. It can either be busy with an actual, model generated message or it can be busy with background traffic. This background traffic is a probabilistic representation of those messages that would be flowing on that net, but are not explicitly modeled in TRACE.

At this time, if all tests (1) through (6) have been successful, the sender is ready to try and make contact with the receiver. The model looks to see if the receiver is still alive (6). If the receiver is "dead" this means that the headquarters company has been destroyed and not yet reformed or been replaced. When this happens there is a long wait (6a) because the sender knows only that he is not getting a response. He has no idea why. All the previous adverse results caused only a short wait (4a or 5a) because it was immediately obvious to the sender why he could not get

through. After several calls however the determination of what to do next follows the same procedures (5b, 5c, 5d) as the short wait results (with the exception of being jammed).

If the receiver is alive, he must be in range (7), have the proper (8), unbusy (9) equipment and not be jammed (10) at this time. If any of these tests fail there is a long wait while the radio operator continues to try and get a response. Then the usual processing of what to do next (5b, 5c, 5d) occurs.

When tests (1) through (10) all succeed the message may be transmitted. All of the above processing has been handled by 2 subroutines. The first, outside the dotted line merely tries to establish contact. The second, inside the dotted line determines what to do when the message can't get through. It is by varying this second routine and its inputs that SOPs are modeled.

3.2.3.2 Message Transmission. At this time there are two means of message transmission. Sending a message by courier takes the courier speed divided into the distance between sender and receiver to get the "time of transmission. Sending a message by radio takes a function of the average message transmission time to get the time of transmission for this message. When a radio is used, one of the sender's radios, one of the receiver's, and the net all become busy. When the message is received they will all become unbusy. The only thing that will prevent a courier message from being received is a dead receiver at time of receipt. Radio messages will be lost if either sender or receiver die at any time during the transmission of the message.

#### 3.2.4 Assumptions

Requests for artillery or CAS support that are over 15 minutes old are considered to be OBE and are discarded without further processing or notifications at any time they are encountered.

#### 3.2.5 Damage to Communications

Conventional - Radios are considered to be in many vehicles of a unit and therefore all rounds fired into a unit can kill radios

- |         |   |   |
|---------|---|---|
| Nuclear | - | All units, of both sides, who are within the minimum Zero-PK range of a blast are checked for damage form nuclear effects.  |
| General | - | No damaged radios are repaired or replaced. When a headquarters unit is slain the next maneuver unit is, after a period of time designated as its replacement. However, all radio equipment the slain unit possessed are lost. During this change over time the unit cannot be communicated with. |

### 3.3 CONVENTIONAL WEAPONS EFFECTIVENESS

The purpose of the conventional weapons effects portion of TRACE is to assess both the attrition of weapons platforms and the degradation of communications capability during conventional weapons attack. This effort entails the development of a single shot probability of kill ( $P_k$ ) for a given weapons system against another weapons system/communications unit. Since this  $P_k$  must be representative for all combat conditions, it does not apply to any specific situation, such as firing at a close in, fully exposed target, and it is therefore a weighted average of  $P_k$ 's for preceived combat conditions.  $P_k$ 's developed for use in this study appear in Table 2. Because of the continuousness of combat these were adjusted based on rate of fire. The adjusted values appear in Table 3.

#### 3.3.1 Weapons Systems Employed

Both Blue and Red forces are given an indirect fire capability in the form of field artillery and a direct fire capability in the form of tanks and antitank units (ATU's). Specific Blue weapons systems modeled are:

- (1) Indirect Fire
  - 155 mm howitzer
  - 8 inch howitzer
  - 175 mm gun
- (2) Direct Fire
  - M60 tank
  - TOW and Dragon ATU's

Table 2. Weighted average  $P_k$ .

| BLUE $P_k$ |       |        |        |        |
|------------|-------|--------|--------|--------|
|            | ATU   | TANK   | ARTY   | ROCKET |
| ATU        | .469  | .414   | .0001  | .0001  |
| TANK       | .137  | .182   | .0001  | .0001  |
| ARTY       | .0029 | .00099 | .00245 | .0001  |

| RED $P_k$ |        |         |       |        |       |        |        |
|-----------|--------|---------|-------|--------|-------|--------|--------|
|           | ATU    | TANK    | ARTY  | ROCKET | JEEP  | TRUCK  | APC    |
| ATU       | .11    | .353    | .0001 | .0001  | .177  | .29    | .26    |
| TANK      | .066   | .225    | .0001 | .0001  | .15   | .166   | .166   |
| ARTY      | .00027 | .000075 | .0045 | .0001  | .0063 | .00155 | .00027 |

Table 3.  $P_k$  per unit time used in TRACE.

| BLUE $P_k$ PER UNIT TIME |       |      |       |        |
|--------------------------|-------|------|-------|--------|
|                          | ATU   | TANK | ARTY  | ROCKET |
| ATU                      | .134  | .114 | .0001 | .0001  |
| TANK                     | .124  | .165 | .0001 | .0001  |
| ARTY                     | .0087 | .003 | .0073 | .0001  |

| RED $P_k$ PER UNIT TIME |        |         |       |        |      |       |        |
|-------------------------|--------|---------|-------|--------|------|-------|--------|
|                         | ATU    | TANK    | ARTY  | ROCKET | JEEP | TRUCK | APC    |
| ATU                     | .025   | .089    | .0001 | .0001  | .04  | .07   | .062   |
| TANK                    | .038   | .134    | .0001 | .0001  | .088 | .098  | .098   |
| ARTY                    | .00135 | .000375 | .0075 | .0001  | .031 | .0077 | .00135 |

Corresponding Red weapons systems modeled are:

(1) Indirect Fire

- 122 mm gun
- 130 mm gun
- 152 mm howitzer

(2) Direct Fire

- M62 tank
- Sagger ATU

3.3.2 Communications Systems

All Blue communications elements are assumed to be located either in jeeps, medium-size trucks (2-1/2 ton), or armored personnel carriers (APC's). A basic assumption underlying the development of communications equipment is that a kill of the vehicle is identical to a kill of the equipment inside it. This assumption must be made because there is data currently available describing lethal areas of communications equipment mounted in vehicles subject to conventional detonations. All munitions effectiveness manuals available at BDM contain lethality data strictly for personnel and certain types of weapons systems and vehicles. Although some protection to equipment may be afforded by the vehicle's structured members/frame it seems reasonable to conclude that a mobility kill will also either render the equipment inside inoperable or highly vulnerable to complete destruction from ensuing fire.

3.3.3 Indirect Fire

Indirect fire rounds are assumed to be distributed about the aimpoint by a bivariate normal distribution of the form

$$f(x,y) = \frac{1}{\sigma_x \sigma_y 2\pi} \exp \left[ -\frac{1}{2} \left( \frac{x^2}{\sigma_x^2} + \frac{y^2}{\sigma_y^2} \right) \right] \quad (1)$$

The rectangular x-y coordinate system is oriented here with the origin at the location of the intended target and the x-axis is perpendicular to the

line of fire  $\sigma_x$  and  $\sigma_y$  represent the standard deviations of the distribution about the x- and y-axes, respectively, and have the formulas:

$$\sigma_x = \sqrt{(1.48 \text{ DEP}_p)^2 + (1.48 \text{ DEP}_M)^2 + (1.48 (.572) \text{ TLE})^2} \quad (2)$$

$$\sigma_y = \sqrt{(1.48 \text{ REP}_p)^2 + (1.48 \text{ REP}_M)^2 + (1.48 (.572) \text{ TLE})^2} \quad (3)$$

$\text{DEP}_p$  = precision deflection error probable

$\text{DEP}_M$  = mean point of impact deflection error probable

$\text{REP}_p$  = precision range error probable

$\text{REP}_M$  = mean point of impact range error probable

$\text{TLE}$  = target location error

$\text{DEP}_p$  and  $\text{REP}_p$  are a measure of distance from a single mean point of impact (MPI) along the x- and y-axes, respectively which contains 50 percent of the burst points from a single weapon at any given time.  $\text{DEP}_M$  and  $\text{REP}_M$  similarly measure the scatter of MPI's about an aimpoint (i.e., the intended target) where it is assumed that the mean of the MPI's is at the aimpoint and that the MPI's are distributed normally about the aimpoint. TLE is a measure of the error in locating the actual target center, and is assumed circular normally distributed. The constant .572 converts this error to DEP and REP for a bivariate normal distribution. The constant 1.48 converts DEP and REP to standard deviations. Since the errors are bivariate normally distributed, their variances are additive, and  $\sigma_x$  and  $\sigma_y$  represent the standard deviations of the convaluated distributions for each individual error.

The DEP's and REP's for specific artillery pieces are provided in references (3) and (4), and evaluated for purposes of this analysis at 2/3 of the weapon's maximum range. A 50 meter TLE is assumed, implying that the intended target is within 50 meters of the aimpoint 50 percent of the time. Since this error represents a measure of reliability of intelligence with regard to actual target location, it can obviously be adjusted as target location information becomes more current, reliable, etc.

Once the above information is known, the only other required information to calculate the intended target's  $P_k$  for a bivariate normal distribution requires a rectangular approximation of the target's lethal area. Another assumption made is that the targets' damage distance function is "cookie cutter", i.e., no damage occurs outside the rectangular bounds and a kill occurs for rounds falling within the bounds (see Figure 13).

Letting  $t_y = \frac{y_0}{REP_T}$  and  $t_x = \frac{x_0}{DEP_T}$ , where  $x$  and  $y$  represent half

of the lethality rectangle's sides along the  $x$ - and  $y$ -axes, respectively, the resulting  $P_k = P_k(x) P_k(y)$  can be calculated from standard normal tables. (Note:  $P_k(x)$  is the probability the round falls between  $-x_0$  and  $+x_0$  and  $P_k(y)$  is the probability the round falls between  $-y_0$  and  $+y_0$ .)

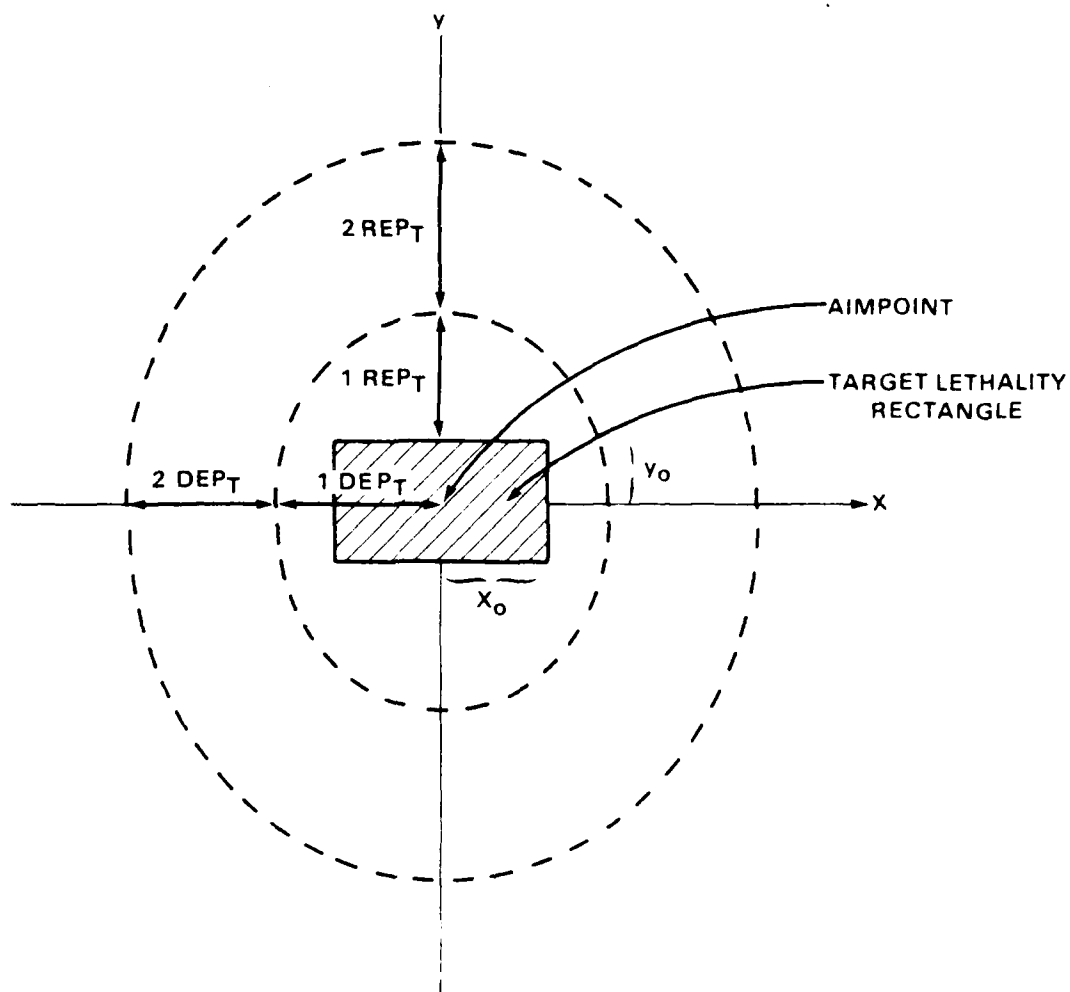
For TRACE, the number of kills are calculated at the end of each time interval (= 64 seconds.) Therefore, the  $P_k$  per unit of time,  $P_k(t)$ , is given by the formula:

$$P(t) = 1 - (1 - P_k)^{FR_i}, \quad (4)$$

where  $FR_i$  represents the firing rate (rounds per 64-second period) of weapon system  $i$ .

Because of the relative broad dispersion of burst points about an aimpoint, a weapon firing into a cluster of targets, such as mobile command post elements, all located greater than a lethal radius apart but still relatively close together, will have a probability of killing other units which is directly proportional to their lethal areas. Formula (5) may be used to calculate the probability that target  $j$  is killed after being fired at by a battery of  $M$  identical weapons for one time interval (each weapon





$$P_K(x) = \int_{-X_0}^{X_0} \frac{1}{\sigma_x \sqrt{2\pi}} e^{-\frac{x^2}{2\sigma_x^2}} dx; \quad P_K(y) = \int_{-Y_0}^{Y_0} \frac{1}{\sigma_y \sqrt{2\pi}} e^{-\frac{y^2}{2\sigma_y^2}} dy$$

$P_K$  = PROBABILITY (ROUND FALLS WITHIN LETHALITY RECTANGLE)  
 $= P_K(x) \times P_K(y)$

Figure 13. Indirect fire lethality pattern

has probability  $P_k(t)$  of hitting target  $j$ , from equation (4) during time interval  $t$  in the  $j$  formula:

$$P_j(t) = 1 - (1 - P_{kj}(t))^M \quad (5)$$

#### 3.3.4 Direct Fire

The problem of determining direct fire probabilities of kill for tanks and anti-tank units (ATU's) is somewhat easier than for the indirect fire case in that it is assumed that 1 direct hit on the target is required in order to register a kill. Also,  $P_k$  data based on statistical samples for selected Red and Blue weapons against selected Blue and Red targets is tabulated as a function of range, target aspects, target speed, type of round and target exposure. (References (3) and (5)). For example, ranges are listed for both the M60 and T62 from 500 to 3000 meters in increments of 500 meters. Target aspect is generally given as  $0^\circ$ ,  $30^\circ$ ,  $60^\circ$ , and  $90^\circ$ , while target exposure is either fully exposed or in hull defilade. The firing weapon is assumed stationary while the target is either stationary, or moving at 10 or 20 KPH. Rounds are either high explosive anti-tank (HEAT) or Armor Piercing.

In order to generate a representative  $P_{kij}$  for weapon  $i$  against target  $j$ , a weighting scheme was used based on the following assumptions:

- (1) All target angles are equally likely,
- (2) All target speeds are equally likely,
- (3) The target was twice as likely to be in hull defilade as fully exposed,
- (4) Opportunities to fire at a target occur 5 percent of the time at 500 and 3000 yards, 15 percent of the time at 1000 and 2500 yards, and 30 percent of the time at 1500 and 2000 yards.
- (5) Armor piercing rounds will be used against armored targets such as tanks while high explosive rounds will be used against soft targets.

Of the above assumptions, (3) and (4) have the greatest effect on the representative  $P_{k_{ij}}$ . All other conditions constant, a target is 10 to 30 times more likely to be hit at 500 yards than at 3000 yards and is 2 to 10 times more likely to be hit fully exposed than in hull defilade. The above weighting scheme implies that a target will attempt to minimize exposure as well as avoid being fired upon at extremely close ranges.

Because of a lack of available data, the  $P_k$ 's most difficult to estimate are those for Red ATU's and tanks against Blue APC's, trucks and jeeps.

A logical way to estimate these  $P_k$ 's is to start with some known baseline  $P_k$  and then extrapolate from there. In this case, the known baseline  $P_k$ 's are against Blue tanks. As with artillery, it is reasonable to assure that the ballistic dispersion of ATU and tank rounds obey a bivariate normal distribution in range and deflection. A normal distribution in range implies a normal distribution in height since the axes are only 90° apart. As with artillery, it is not unreasonable to assume a small deflection error (1 meter or less) at the close ranges (500 - 3000 meters) where tank and anti-tank combat occurs. If deflection error were fixed at 1 meter, then knowledge of the target's (in this case a Blue tank) dimensions plus the  $P_k$  allows "working backward" to determine the height probable error. Once this error is known, then the  $P_k$ 's against Blue APC's, trucks, and jeeps can be computed based on their dimensions.

In summary, a list of factors affecting conventional weapons  $P_k$ 's would include the following:

- Range
- Target size and area
- Target lethal area
- Weapon system accuracy
- Shell reliability
- Target exposure
- Target identification (camouflage)
- Target movement

- Target location error
- Target counterfire
- Atmospheric conditions/weather/visibility
- Terrain
- Training/readiness of personnel

Some factors, such as range and system accuracy are relatively easy to model, while others, such as terrain and personnel readiness, cannot be easily quantified and incorporated into a general model.

### 3.4 NUCLEAR WEAPONS EFFECTS

#### 3.4.1 On Communications

No communications related nuclear weapons effects (NWE) existed in the version of TCOR-II used for TRACE. In fact, communications were considered invulnerable to any weapons effects or attrition. In order to provide the simulation with a credible effects of the battle on the communications, other than message traffic load, a nuclear weapons effects (NWE) module was created. This module consisted of seven submodules designed to simulate the effects of low altitude nuclear bursts on all of the communications equipment to be used by Blue forces in this model. Each of these submodules was developed to perform high speed curve fits based on range to DGZ and yield of the weapon. The details of developing one of these, called PKPERS, are completely explained in Appendix B. The other routines were developed in a similar fashion. The seven submodules are:

- (1) PKPERS: This submodule calculates the approximate probability that a person will be rendered inoperative as a result of exposure to a low altitude detonation.
- (2) PKRATT: This submodule calculates the approximate probability that a standard Army RATT man-machine communications system will be rendered inoperatable as a result of exposure to a low altitude detonation.
- (3) PKFMRD: This submodular calculates the approximate probability that or FM radio from the AN/VRC-12 family, is rendered inoperative due to exposure to a low altitude detonation. EMP and treeblowdown are implicitly included.

- (4) PKMICW: This submodule calculates the approximate probability that a standard Army microwave multichannel communication system will become inoperable as a result of exposure to a low altitude detonation.
- (5) PKM151: This submodule calculates the approximate probability that a standard Army M151 vehicle will be overturned from the blast wave from a low altitude nuclear detonation.
- (6) PKM35A: This submodule calculates the approximate probability that a standard Army M35A vehicle with an S-280 shelter will be overturned by the blast wave from a low altitude nuclear detonation.
- (7) PKM715: This submodule calculates the approximate probability that a standard Army M715 vehicle with an S-250 shelter will be overturned by the blast wave from a low altitude detonation.

#### 3.4.2 In General

Along with the communications NWE, the NWE module was provided with a submodule for general damage to a unit by a nuclear weapon. The general equation shown in equation 1 was developed from the data in references 4, and 6.

$$P_k = 2e^{-\left(.695 \frac{df}{\pi R_H^2}\right)} \quad \text{for a random placement} \quad (\text{Eq.1})$$

In TCOR-II the radius ( $R_H$ ) of a level 3 hex is 1.35km. The dispersion factor (df) used in the nuclear environment was 11.5 when companies had to occupy the entire hex. Thus, equation 1 reduces to

$$P_k \cong .50 \quad (\text{Eq.2})$$

This was the factor used in the NWE submodule. The basic  $P_k$  value could have been modified due to hex occupancy which would vary the dispersion factor. However, all fire support, both nuclear and conventional, on the TCOR-II model was uncorrected. No forward observer guided the fires nor

even made sure the target was still there. For this reason the unmodified  $P_k$  was deemed to be of an accuracy consistent with the aggregation of the fire support processes.

### 3.5 POST-PROCESSING

No suitable post-processing or information gathering software existed at the stage in the development of TCOR that the TRACE project used as a starting point. Rather than wait for their development the TRACE project developed a general purposes that allowed close examination of the items believed to be of interest. The information produced proved so valuable that these modules have been inserted into other metric family simulations. Three basic items were developed:

- (1) Check point unload and reload
- (2) Communications file
- (3) Status file

#### 3.5.1 Check Point Unload and Reload

It is extremely valuable when working with a simulation to be able to restart a particular simulation at some point in time other than the beginning. The value of this is no less during the experiments then it is during actual testing and development.

The procedures for doing this is very simple. It requires that all data that the simulation is dependent on be copied to a file at periodic intervals. Each copy or dump is called a checkpoint. Some data items are reconstructed or recalculated each time they are to be used due to the highly dynamic nature of their components. An example of this is a list of targets within direct fire range of a unit. The simulation is not "dependent" on such data, though it may be on their components.

This enhancement included a two associated abilities. First the simulation was able to pick any user specified start time from a file of checkpoints. Second, the periodicity of the checkpoints could be set by the user, to any integral number of seconds at the beginning of any start or restart.

#### 3.5.2 Communications File

To facilitate the study of communications behavior, a file was created that contained all messages recieved by the Blue commander.

Messages were ordered by their receipt time. This time was also stored with the message. By use of this file the order and timeliness of the message traffic received could be studied.

This file proved especially usefull in the conduct of the experiment. It enabled an exact determination of the knowledge available in the command headquarters at any instant. From this information a MITL can be briefed on the situation of friendly and enemy forces. The amount and accuracy of the information is directly related to the state of the communications.

### 3.5.3 Status File

The status file consisted of "results" from the simulation. A separate post processor module was created to display the data according to user directed formats. One of these display is the map of the battle field. Appendix F shows example of the maps and gives a key for interpretation. Also, available through this module are unit status historys showing resources remaining, message traffic statistics, and unit movement traces. The details of using this module are completely explained in and examples are given of all the possible outputs in reference 2.

This post processor provide most of the data used in the analysis in this study.

## 3.6 C<sup>3</sup> ENHANCEMENTS

TCOR-II's awareness of its battlefield environment, at the time the TRACE study diverged in development, was at a very mininal level. Movement was affected by the perceived value of chosing between paths and certain responses were programmed to the stimuli of enemy sighting or receipt of direct fire. The following stimuse were ignored:

- (1) Nuclear detonations
- (2) Unit destruction (friendly or enemy)
- (3) Intelligence messages
- (4) Loss of headquarters
- (5) Receipt of obsolete artillery/CAS requests (the mission was executed anyway)
- (6) No orders or inappropriate orders

- (7) More targets than can be effectively engaged
- (8) Receipt of status reports
- (9) Receipt of indirect fire
- (10) Orders with regard to reconnaissance or headquarters units.

It was clear that some of these stimuli would have to be reacted to in order to study the effects of communications. Communications is a tool of the C<sup>3</sup>I process much more than the physical combat. Previously the sole effect of no communications is that artillery fire would arrive late. However, the TRACE project was a communications study not a simulations development contract. Thus, the amount of perception/plan/replan ability developed would have to be limited. The following paragraphs give a briefed explanation of each of the C<sup>3</sup>I enhancements implemented.

#### 3.6.1 Stimulus: Nuclear Detonation

Whenever a detonation occurred a description status message was entered into the communications system. Other than the load on communications, no other response was developed.

#### 3.6.2 Stimulus: Unit Destruction

Whenever a unit was observed to be destroyed a report was entered into the communications system. Upon receipt of this message, the destroyed unit was removed from the headquarters perceptions list. This produced more effective planning of orders. The "observing" unit(s) had to be able to perceive the destroyed unit in order to be aware of its destruction.

#### 3.6.3 Stimulus: Intelligence Messages

The enemy unit specified in the message was added to or updated on the receiving headquarters perceptions list. On a probability basis, indirect artillery fire was requested by the headquarters. (This fire proved to be totally ineffective so may be discounted as a result. There was, however, the associated message.)

#### 3.6.4 Stimulus: Loss Of A Headquarters

The loss of a headquarters unit is very serious stimulus, especially in a communications study. When ever this happened one of the units under that headquarters would assume the function of the headquarters



after a time delay. During this delay no messages could be sent or received by that organization other than internally or to direct support units. Any messages sent by courier were simply lost.

#### 3.6.5 Stimulus: Receipt Of Obsolete Artillery/CAS Requests

Throughout the simulation, anytime any unit handled a support request that was over 15 minutes old, it considered the request OBE and discarded it from the system. The main effect of this was to reduce the backup of message traffic and to make the FDCs move effective. In conjunction with this a change was made to the support request procedure. Rather than being able to request fire against every enemy target, every combat interval (64 seconds), by every friendly unit in combat, the procedure was changed to permit one request per unit in contract per interval.

#### 3.6.6 Stimulus: Reconnaissance And Headquarters Unit Orders

Prior to this enhancements Reconnaissance and Headquarters units never moved unless they came under direct fire. The had two effects with regard to C<sup>3</sup>I. The first was that, in an advance, the headquarters were soon left far behind which gave unrealistic communications safety and messenger delivery times. It also distorted a higher units perception of where its subordinates were. The second effect was that the intelligence traffic expected from reconnaissance units was nonexistent. The simulation was enhanced such that both of these unit types would follow orders but operated on a fire and flee plan. Before this, they had just fled. In conjunction with this, when a unit took casualties beyond its limit, it no longer retreated away from the enemy. It retreated towards its headquarters. "Away from the enemy" has the possibility of being in any direction at all because the entire world had not been modeled.

## SECTION 4

### CASES EXAMINED

#### 4.1 GENERAL

The prototype TRACE model was used to conduct four basic experiments that lead to a first-order quantification of tactical communications effectiveness. Specifically, these four cases explore the progress and outcome of ground combat operations for degraded and non-degraded communications in conventional and mixed nuclear-conventional weapons environments. Each of the four cases employs the same conflict scenario, combat resources, and military objectives. This section sets forth the preceding parameters while the results and analysis of the computer runs are presented in the subsequent section. A complete listing of all initial input values to the model is included in Appendix C.

#### 4.2 TRACE PROTOTYPE TEST SCENARIO

In formulating a conflict scenario to test the prototype TRACE model and at the same time gain insight into the value of communications on the tactical battlefield, two main considerations were observed. First, neither side should have an overwhelming force advantage which could easily overshadow the role of communications as well as bring the conflict to a close too quickly. Clearly, whatever force multiplier effect communications may have, there is a point beyond which no amount of communications can overcome a force imbalance. Secondly, the total size of the opposing forces should be kept as small as possible to facilitate validation and checkout of the added capabilities and processes of the TRACE model without compromising the credibility of results from the experimental test cases.

Since the basic TCOR model from which TRACE is derived does not yet incorporate terrain/weather effects on more than a "zeroth-order" basis, the specific geographic location of the conflict is irrelevant as far as the model processes are concerned. Even so, the geographic setting may be taken to be the Fulda gap area in Central Europe.

The scenario represents a Red tank division breaking through the defensive line held by a Blue armored division. The purpose of these runs

was to determine the relationship that communications has to the battle outcome. For this reason, standard TO&E divisions have been used in both cases as opposed to modeling any particular divisions.

The Blue division is defending with two balanced brigades forward and an armor-heavy brigade in reserve (see Figure 14). The Red division is breaking through on a shorter frontage (see Figure 15). Red has divided its forces into a division two echelon attack. The Red division has a tank and a motorized rifle regiment in the division first echelon supported by the divisional artillery and one attached artillery brigade from Army assets. After the initial breakthrough, the division second echelon, two tank regiments, assumes the attack and the divisional artillery switches to supporting them.

The Red plan is to contain and pin down the enemy as much as possible while penetrating deep into the rear area. Referring to Figure 3, the division first echelon will penetrate the lines using the infantry to pin the forces on the right flank. The tank regiment will push forward. This happens in the first 1-2 hours of conflict. The division second echelon will swing a little to the right to envelope the pinned forces, contain them, and then link with the division first echelon and press on. The Red plan is to have this breakthrough complete and ready for army second echelon exploitation in 7 hours maximum.

The respective force strengths for each combatant are summarized in Tables 4 and 5. A detailed breakdown of force structures and strengths can be found in Appendix C. Tables 4 and 5 exclude headquarters units because they do not enter combat even though they can defend and be attrited. Finally, Figures 16 and 17 show the respective force structures in military symbology.

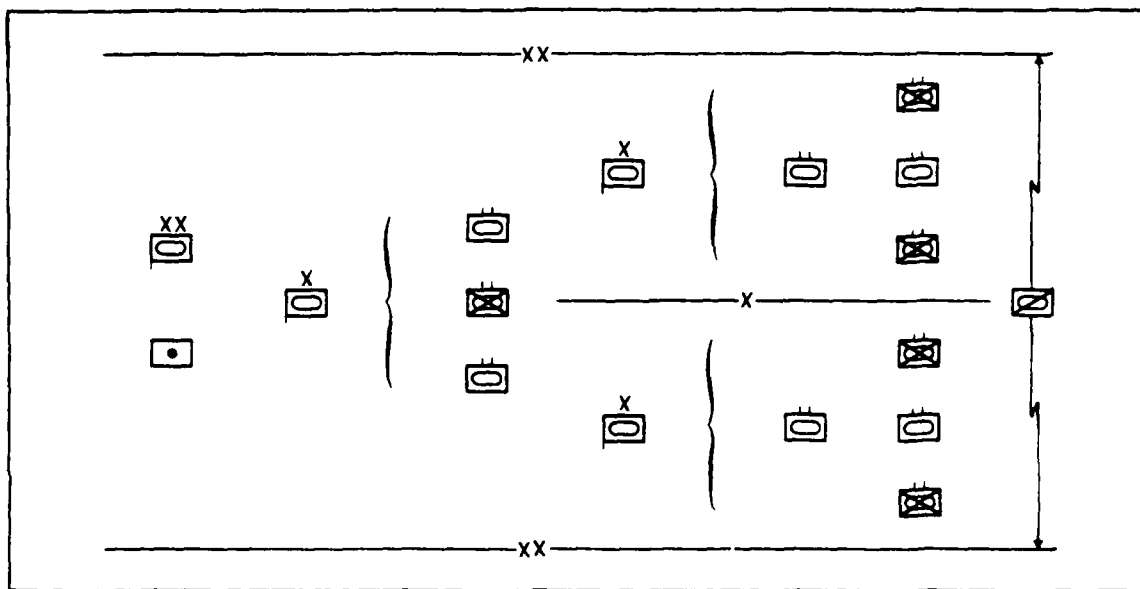


Figure 14. Blue deployment

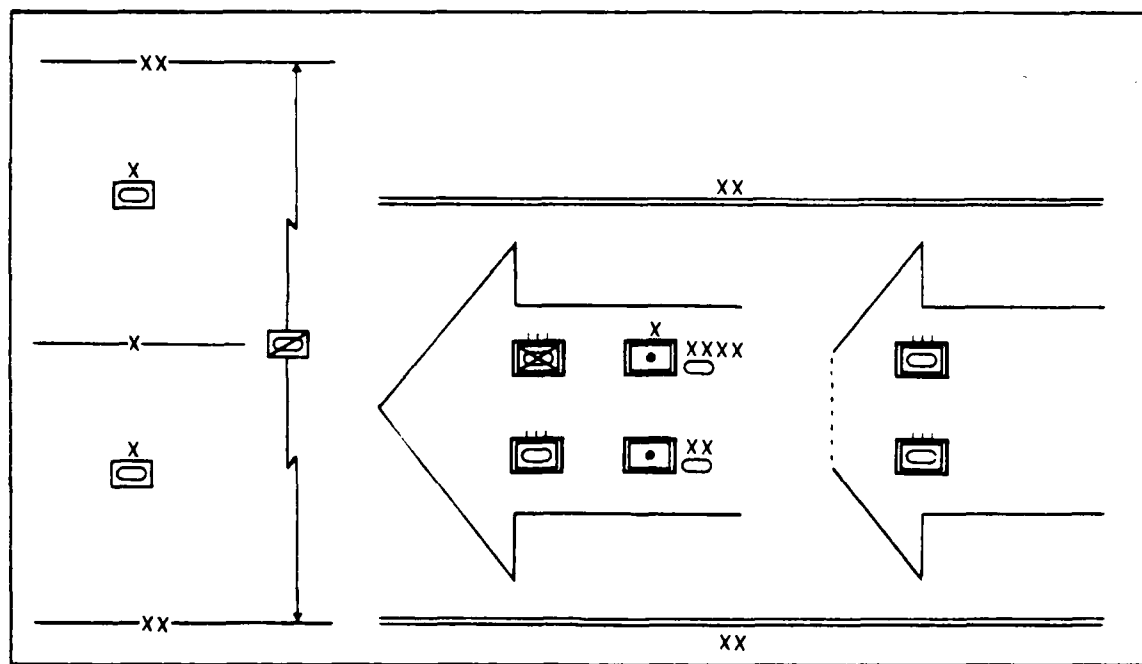


Figure 15. Red deployment



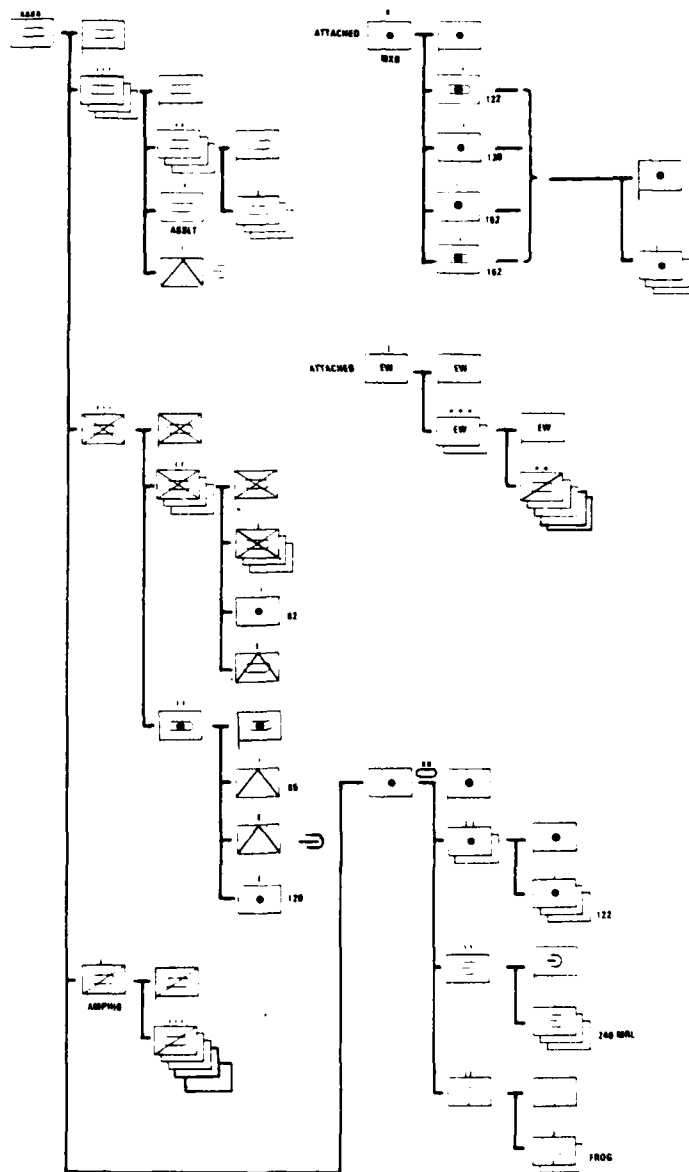


Figure 17. Red Forces.

Table 4. Blue force strength summary.

|          | Units   | APCs | ATUs | Tubes | Tanks | Rounds |
|----------|---------|------|------|-------|-------|--------|
| 1st Bde  | 16 Co.  | 78   | -    | 10    | 142   | 10994  |
| 2nd Bde  | 16 Co.  | 78   | -    | 10    | 142   | 10994  |
| 3rd Bde  | 12 Co.  | 39   | -    | 6     | 132   | 9550   |
| Div Arty | 12 Bty. | -    | -    | 66    | -     | 14316  |
| Recon    | 5 Co.   | 54   | 8    | 3     | 27    | 3453   |
| Totals   | 61      | 249  | 8    | 95    | 443   | 49307  |

Table 5. Red force strength summary.

|                 | Units      | APCs | ATUs | Tubes | Tanks | Rounds |
|-----------------|------------|------|------|-------|-------|--------|
| First Echelon   |            |      |      |       |       |        |
| 1st Reg.        | 11 Co.     | -    | 6    | -     | 100   | 4091   |
| 2nd Reg.        | 17 Co. and |      |      |       |       |        |
|                 | 4 Bty      | 81   | 30   | 12    | 30    | 3750   |
| 3rd ACS         | 5 Plt.     | -    | 10   | -     | 15    | 1500   |
| 4th Arty Bde    | 12 Bty.    | -    | -    | 36    | -     | 5100   |
| 7th Div Arty    | 9 Bty.     | -    | -    | 54    | -     | 6378   |
| 8th Recon. Reg. | 10 Co.     | -    | 10   | -     | -     | 310    |
| Second Echelon  |            |      |      |       |       |        |
| 5th Tank Reg.   | 11 Co.     | -    | 6    | -     | 100   | 4091   |
| 6th Tank Reg.   | 11 Co.     | -    | 6    | -     | 100   | 4091   |
| Totals          | 90         | 81   | 68   | 102   | 345   | 29311  |



#### 4.3 MITL INTERFACE

The TCOR model does not have a highly developed capability to automatically assimilate battlefield status and intelligence information and from this make command decisions. Since the ability to make such decisions is intimately related to communications, the Man-in-the-Loop (MITL) capability of the model was employed to provide high level command control decisions. All four experimental cases were conducted in the manner described below.

A BDM staff member with a previous U.S. Army career as a field grade officer and not associated with this project was selected to be the Blue Division commander. His previous experience included many staff and command positions in tactical combat operations. No equivalent was designated for Red; the model would be allowed to conduct all Red operations with human interfaces conducted by the TRACE project staff should they become necessary.

Beginning at time zero, the model was allowed to simulate five hours of combat and halted. In addition to all of the normal statistical data, restart information was written to a storage file every 30 simulated minutes so that the battle could be resumed at any of these time points. Starting at time zero was a matter of convenience since there is no day/night differentiation in the model.

Using a piece of 18 x 24 inch clear acetate and red and blue grease pencils, the project staff generated a situation map overlay at hour two (02:00 hours). The situation thus recorded was deduced strictly from the communications status and intelligence reports received during that two hour interval.

The MITL (Blue Division Commander) was then called to review the situation and redirect the battle as he saw fit with no encouragement from the project staff. After assessing the situation, he transferred his decisions directly to the situation overlay and the project staff subsequently converted these decisions into model inputs. The model was then allowed to simulate another five hours of combat starting at the hour-two MITL interface point.

At hour four (04:00 hours) the entire process was repeated with a new situation map and MITL interface. If the MITL decided at any interface not to change or give any new orders, no computer run would be required because we had allowed for five hours of combat and a new situation map could be generated two hours of combat later immediately. In actuality the MITL did effect changes at each two-hour situation review in all four cases examined. Each case was explored for a total of eight and one-half hours and therefore MITL interfaces occurred at two, four, six, and eight hours. Although a smaller review interval could have been selected at any time (in 30 minute increments because of the restart point written) this was found to be unnecessary by the TRACE staff as each two-hour situation map was generated.

In Cases III and IV, each side was permitted to employ up to 16 tactical nuclear weapons. All Blue nuclear strikes were under the direct control of the MITL while the Red strikes were controlled by the model logic.

## SECTION 5

### RESULTS AND ANALYSIS

#### 5.1 INTRODUCTION

The results of the four cases examined with the prototype TRACE model are presented in this section. Those cases are:

- I Conventional Warfare - Unimpaired Communications
- II Conventional Warfare - Degraded Communications
- III Nuclear Warfare - Unimpaired Communications
- IV Nuclear Warfare - Degraded Communications

The initial conditions, scenario, resources and military objectives are identical for all cases as identified in Section IV. Furthermore, the actions of the Blue Division Commander were effected through human interaction with the model as was also explained in Section IV.

Later in this Section, the reader will notice the appearance of two additional cases denoted by Cases III-FP and IV-FP. The abbreviation FP stands for Free Play and means that both Red and Blue combatants were allowed to employ their sixteen tactical nuclear weapons according to the TRACE model criteria. Furthermore, there was no MITL intervention in these two cases which means that only two computer runs were required and that the model itself made all Blue decisions as well as Red. At first, these runs were only intended as checkout but the results were interesting enough to include in this report for comparison with the MITL interactive cases.

This section contains a large number of full page charts and graphs. To enhance textual continuity and clarity, all figures have been grouped in their order of reference and placed at the end of the section.

#### 5.2 COMBAT RESOURCE DRAWDOWN

It is a generally accepted military belief that good communications permit a more effective use of given resources or mission accomplishment with fewer resources than might otherwise be required in a poor communications environment. The resources (as recognized by the TRACE model) are infantry units, armor units, artillery pieces, and ammunition. Table 6 summarizes Blue Division resources remaining at 05:30 and 08:30 as

a percentage of the initial quantities for each of the six TRACE cases examined.

Table 6. Percentage of Blue Division resources remaining at 05:30 and 08:30

| Case   | 05:30 |       |      |      | 08:30 |       |      |      |
|--------|-------|-------|------|------|-------|-------|------|------|
|        | Inf   | Armor | Arty | Ammo | Inf   | Armor | Arty | Ammo |
| I      | 81.7  | 78.8  | 93.7 | 15.0 | 80.5  | 72.0  | 90.5 | 13.4 |
| II     | 80.2  | 74.7  | 75.8 | 9.7  | 79.4  | 73.4  | 75.8 | 6.7  |
| III    | 72.4  | 80.8  | 72.6 | 34.0 | 70.8  | 77.9  | 67.4 | 15.7 |
| IV     | 77.8  | 74.5  | 84.2 | 24.5 | 76.3  | 67.7  | 80.0 | 12.6 |
| III-FP | 78.6  | 77.2  | 76.8 | 31.6 | 72.8  | 73.1  | 69.5 | 22.7 |
| IV-FP  | 78.2  | 78.8  | 88.4 | 42.6 | 73.2  | 72.2  | 75.8 | 23.5 |

The dynamic drawdown of these resources is shown graphically in 30 minute increments for each of the six cases in Appendix D. The selection of the 05:30 and 08:30 time points for reporting result summaries is based on the Blue defense objectives -- hold a phaseline approximately parallel to, and eight kilometers behind, the initial FEBA until 05:30 and hold a second phaseline coincident with the Division rear boundary.

Although Appendix D portrays ammunition drawdown for the six cases, it is also included here in Figures 18 and 19 to facilitate comparison among them. Note that Cases III and IV appear in both figures so that Figure 18 encompasses the four MITL cases while Figure 19 the four nuclear cases.

Both of these figures clearly demonstrate a significant delay in ammunition expenditure and thus combat engagement due to degraded Blue communications. Figure 18 also shows that ammunition expenditure in the degraded communications cases eventually surpasses that of the non-degraded cases. This effect is attributable to degraded communications in conjunction with the MITL's aggressiveness in trying to halt the Red advance. The Blue Division commander ordered elements of the First and Third Brigades to

move into blocking positions that channeled the advancing Red force along his existing route of advance. This would eventually lead to a pinch-off and encirclement of the Red forces. Delayed communications, however, allowed the Red forces to penetrate deeper as well as mass more forces along the march route resulting in a more intense battle with the ensuing greater losses. Referring to Figure 19, we see that the model alone (without MITL intervention) plays a more conservative game and, in the end, shows virtually no difference in ammunition expenditure.

Later in this Section, we will investigate more closely the loss of other resources as well as Red penetration and ground gained.

Referring back to Table 6 and comparing Case I to II and III to IV, we generally see fewer resources expended/lost at the same point in time when Blue communications is unimpaired. The significant exceptions occur in Cases III and IV and this is primarily due to the self-inflicted losses from tactical nuclear weapons employment. Later in this section there is a tabular summary of all losses incurred to both sides by all nuclear strikes. (The 16 nuclear weapons allotted to each side are not included in the ammunition count and are treated separately.) The somewhat surprising result occurs in cases III-FP and IV-FP where, at battle's end, there is virtually no difference in resources expended/lost. Table 7 presents the same resource summary for the Red side.

Table 7. Percentage of Red resources remaining at 05:30 and 08:30

| Case   | 05:30 |       |      |      | 08:30 |       |      |      |
|--------|-------|-------|------|------|-------|-------|------|------|
|        | Inf   | Armor | Arty | Ammo | Inf   | Armor | Arty | Ammo |
| I      | 51.7  | 77.7  | 100. | 11.8 | 44.3  | 71.9  | 100. | 2.8  |
| II     | 66.4  | 69.9  | 98.0 | 9.3  | 57.7  | 68.4  | 95.1 | 4.8  |
| III    | 36.2  | 73.3  | 98.0 | 15.4 | 28.2  | 59.7  | 98.0 | 5.6  |
| IV     | 42.3  | 60.6  | 97.1 | 14.4 | 41.6  | 51.0  | 97.1 | 5.3  |
| III-FP | 27.5  | 63.5  | 90.2 | 26.9 | 22.8  | 53.3  | 100. | 12.7 |
| IV-FP  | 57.7  | 71.6  | 93.1 | 31.4 | 54.5  | 54.8  | 93.1 | 13.0 |

With the exception of ammunition expenditure, Red generally expends/loses fewer resources when Blue communications is degraded. This effect is most noticeable in the FP cases (e.g., non-MITL) even though there is virtually no difference in ammunition expenditure as was true for Blue. The percentages reported in Tables 6 and 7 were based on the resources of just the combat maneuver units which basically excludes the Headquarters units. Table 8 below summarizes the total combat expendable resources for each side so that numerical quantities may be determined as desired. (A more detailed breakdown of these resources appears in Section 4.)

Table 8. Total initial combat resources that are expendable in combat.

| Side | Infantry Units | Armor Units | Artillery Tubes | Ammo Rounds | Nukes |
|------|----------------|-------------|-----------------|-------------|-------|
| Blue | 257            | 443         | 95              | 49300       | 16    |
| Red  | 149            | 354         | 102             | 29311       | 16    |

### 5.3 COMBAT UNIT DRAWDOWN

The combat resources (shown in Table 8) of each player are organized into Company and Battery level units. For the Blue side there are 61 of these units capable of engaging in combat initially. The distribution of the 61 units is:

- (1) 29 armored companies,
- (2) 15 infantry companies,
- (3) 12 division artillery batteries,
- (4) 3 reconnaissance companies, and
- (5) 2 anti-tank companies.

This list excludes the two Lance Batteries each having 16 tactical nuclear weapon rounds.

Figures 20, 21, and 22 show the number of these 61 units that are combat effective over the course of the battle. A combat effective unit is

defined here as a unit that is not dead and has ammunition left. This definition is due strictly to the lack of a model post-game processing capability that employs a threshold level to categorize a unit as being combat effective or not. It turns out that at each 30-minute reading and count of units, those assessed as combat effective almost always had at least ten percent of their basic ammunition load.

All three figures demonstrate the initial reduction of Blue losses due to degraded Blue communications. This is primarily attributable to the slower responsiveness of the First and Third brigades to the Red thrust into the Second brigade. Eventually, however, the degraded communications leads to fewer combat effective units remaining after the battle. Once again, it must be remembered that the actions of the MITL played heavily in the results portrayed in Cases I through IV. Somewhat surprisingly, the two FP cases end with the same number of combat effective units left while at the same time showing the same degraded communications delay effect. We note also that the more consistent and conservative play of the model in an FP mode leads to a greater number of combat effective units remaining at conflict's end. This is even more striking in view of the low usage of nuclear weapons in Cases III and IV.

#### 5.4 NUCLEAR STRIKES

This section is intended to simply present a summary of the total damages incurred by all tactical nuclear strikes as well as their target locations and timing. Figure 23 shows the dynamic expenditure of the tactical nuclear weapons for both sides of each of the four nuclear cases. Table 9 summarizes the total losses caused by those strikes on both friendly and enemy forces in terms of units of infantry and armor (not companies) and artillery tubes.

Table 9. Summary of total combat losses due to nuclear strikes.

| Case   | Blue Losses |    |       |    |      |    | Red Losses |    |       |    |      |    |
|--------|-------------|----|-------|----|------|----|------------|----|-------|----|------|----|
|        | Infantry    |    | Armor |    | Arty |    | Infantry   |    | Armor |    | Arty |    |
|        | BS          | RS | BS    | RS | BS   | RS | BS         | RS | BS    | RS | BS   | RS |
| III    | 5           | 15 | 5     | 26 | 1    | 1  | 18         | 10 | 33    | 0  | 0    | 0  |
| IV     | 0           | 7  | 17    | 16 | 0    | 2  | 22         | 0  | 9     | 0  | 0    | 0  |
| III-FP | 6           | 11 | 7     | 48 | 0    | 2  | 33         | 13 | 30    | 9  | 0    | 0  |
| IV-FP  | 0           | 9  | 13    | 13 | 1    | 1  | 15         | 0  | 59    | 0  | 0    | 0  |

BS = Blue Strikes, RS = Red Strikes

Referring to Figure 23, comparison of the free-play cases (III-FP and IV-FP) reveals that fewer nuclear weapons were employed by both sides in the degraded communications case as well as a delay in their release. There is only one direct effect of communications performance on nuclear artillery (or conventional for that matter) and that is the time for the support request from the requesting unit to be sent to the artillery battery. Referring again to Figure 23, there is an implication that degraded communications results in a lower utilization of tactical nuclear weapons but, this is not necessarily the case although degraded communications is most certainly an indirect factor. In all four cases (III, IV, III-FP, and IV-FP) Red communications is undegraded and Red nuclear strikes are controlled and directed by the TRACE model criteria. Blue strikes, on the other hand, are model controlled only in the free-play cases. The MITL directed strikes in Cases III and IV are both immediate and totally independent of communications. The foregoing caveats are intended to preclude the reader from hastily drawing potentially erroneous conclusions regarding nuclear strikes vis-a-vis the state of Blue communications. We also reiterate that the Blue Division commander (MITL) had directed his six remaining nuclear weapons be used at 06:00 hours in Case IV but that they did not detonate for an undetermined reason.



Finally, we must also consider the model criteria for tactical nuclear weapon strikes. When two opposing units are engaged in combat, their status is updated every 64 seconds (continuous combat within 64 second discrete time intervals). During each of these time intervals there is a 15 percent chance that a unit will request artillery support. If nuclear artillery support is permitted for this unit and the unit is at or above its casualty limit, then a nuclear strike request is issued to the appropriate firing battery. The casualty limit is specified by the user (75 percent for the six TRACE cases) and is compared to the average of the fractional amounts of each initial resource expended/lost for the unit. Each possible resource (infantry, armor, artillery, rockets, and ammunition) has equal weight in determining the casualty average which, in turn, can potentially lead to an occasional unexpected result.

The nuclear strike losses data shown earlier in Table 9 can be reduced and transformed into a percentage of "friendly" losses form as shown in Table 10 below.

Table 10. Friendly losses as a percentage of total losses incurred by nuclear strikes.

| Case   | Blue | Red  |
|--------|------|------|
| III    | 17.7 | 19.2 |
| IV     | 35.4 | 0    |
| III-FP | 17.1 | 26.5 |
| IV-FP  | 15.9 | 0    |

In Case IV, over 35 percent of all losses due to Blue strikes against Red forces resulted in Blue losses. This is primarily attributable to the somewhat fatalistic attitude taken by the MITL toward his virtually neutralized 2nd Brigade forces as well as the failure of the model to detonate the six Blue nuclear weapons at 06:00 which would have resulted in a greater kill of Red forces and much fewer to Blue. Model directed nuclear strikes do not account for friendly forces in proximity to the

target which partially explains the Red results. The fact that Red incurred no damages to himself due to his own strikes against Blue in the degraded Blue communications cases is probably not strongly related to the degrade itself. The result is due primarily to the lower number of Red strikes and strikes at targets where there are no or very few closely located Red units.

In completing this section, we present Table 11 summarizing the precise time and hexagonal coordinate location of each nuclear strike.

#### 5.5 COMMUNICATIONS PERFORMANCE

There are four basic types of communications in TRACE that have a direct and immediate impact on the progress and outcome of a combat operation. They are: combat orders, status and situation reports, intelligence information reports, and artillery support requests. Communications with respect to air operations are not included only because air operations did not play a significant role in the prototype TRACE cases. Other types of communications become increasingly important (such as resupply) in proportion to the duration of the conflict which is not a key factor in the TRACE cases.

Tables 12, 13, 14, and 15 summarize the dynamic flow of communications traffic for each message type respectively for the six TRACE cases examined. The total number of messages successfully completed and the average message delivery time for them are shown over time for each case. It is important to realize that these communications messages are strictly the successful ones excluding all messages that may have been generated but were unsuccessful for any reason. Unfortunately, the TRACE game post-processing capability is insufficient to support report generation of all communications related events independent of their initial or ultimate dispositions.

The columns in Tables 12, 13, 14, and 15 were aggregated and those results are presented in Table 16. Two interesting features are revealed by this table as follows. First, there is roughly an order-of-magnitude increase in message transmission time for orders and reports and

Table 11. Time and target hex location of all nuclear strikes by case.

| III |         |       | IV |         |       | III-FP |         |       | IV-FP |         |       |
|-----|---------|-------|----|---------|-------|--------|---------|-------|-------|---------|-------|
| S   | Time    | Loc   | S  | Time    | Loc   | S      | Time    | Loc   | S     | Time    | Loc   |
| R   | 1:23:25 | 72634 | R  | 1:53:57 | 76375 | R      | 1:23:25 | 72634 | B     | 1:44:44 | 76311 |
| R   | 1:23:25 | 72634 | R  | 1:53:57 | 76375 | R      | 1:23:25 | 72634 | B     | 1:54:41 | 76317 |
| R   | 1:25:55 | 72422 | B  | 2:00:10 | 72422 | R      | 1:25:55 | 72422 | R     | 2:11:39 | 76367 |
| R   | 1:25:55 | 72422 | B  | 2:00:10 | 72426 | R      | 1:25:55 | 72422 | R     | 2:11:39 | 76367 |
| R   | 1:28:25 | 72644 | B  | 2:00:10 | 72463 | R      | 1:28:25 | 72644 | R     | 2:22:13 | 76314 |
| R   | 1:28:25 | 72644 | B  | 2:00:10 | 76315 | R      | 1:28:25 | 72644 | R     | 2:22:13 | 76314 |
| R   | 1:30:55 | 72644 | B  | 2:00:10 | 76311 | R      | 1:30:55 | 72644 | B     | 2:22:14 | 76364 |
| R   | 1:30:55 | 72644 | B  | 2:00:10 | 76313 | R      | 1:30:55 | 72644 | B     | 2:24:44 | 72426 |
| B   | 2:01:00 | 72462 | B  | 2:00:10 | 76335 | B      | 1:34:56 | 72676 | B     | 2:27:14 | 76317 |
| B   | 2:01:00 | 72422 | B  | 2:00:10 | 72644 | B      | 1:34:56 | 72647 | R     | 2:27:29 | 76314 |
| B   | 2:01:00 | 72643 | B  | 2:00:10 | 76337 | B      | 1:37:26 | 72647 | R     | 2:27:29 | 76314 |
| B   | 2:01:00 | 72644 | B  | 2:00:10 | 76331 | B      | 1:37:26 | 76311 | R     | 2:29:59 | 76314 |
| B   | 2:01:00 | 72665 | R  | 6:01:00 | 72766 | B      | 1:39:56 | 72462 | R     | 2:34:17 | 76314 |
| B   | 2:01:00 | 76351 | R  | 6:03:30 | 72766 | B      | 1:39:56 | 72647 | B     | 2:55:24 | 76373 |
| B   | 2:01:00 | 76334 |    |         |       | B      | 1:42:26 | 72644 | B     | 3:34:16 | 76311 |
| B   | 2:01:00 | 72666 |    |         |       | B      | 1:42:26 | 76335 | B     | 4:53:56 | 72422 |
| B   | 2:01:00 | 76311 |    |         |       | B      | 1:44:56 | 72643 | B     | 5:53:16 | 76331 |
| B   | 2:01:00 | 76313 |    |         |       | B      | 1:44:56 | 76317 | B     | 5:55:04 | 72431 |
| R   | 2:09:52 | 72427 |    |         |       | B      | 1:47:26 | 76315 | B     | 6:00:47 | 72431 |
| R   | 2:09:52 | 72427 |    |         |       | B      | 1:47:26 | 76351 |       |         |       |
| R   | 2:20:19 | 72645 |    |         |       | B      | 1:49:56 | 72647 |       |         |       |
| R   | 2:20:19 | 72645 |    |         |       | B      | 1:49:56 | 76315 |       |         |       |
| R   | 2:28:16 | 72645 |    |         |       | B      | 1:53:24 | 72642 |       |         |       |
| R   | 2:28:16 | 72645 |    |         |       | B      | 1:53:24 | 72641 |       |         |       |
| R   | 2:33:58 | 72645 |    |         |       | R      | 2:09:23 | 72462 |       |         |       |
| R   | 2:33:58 | 72645 |    |         |       | R      | 2:11:53 | 72462 |       |         |       |
| B   | 6:00:10 | 72667 |    |         |       | R      | 2:20:36 | 76314 |       |         |       |
| B   | 6:00:10 | 72742 |    |         |       | R      | 2:25:05 | 76314 |       |         |       |
| B   | 6:00:10 | 72655 |    |         |       | R      | 2:25:05 | 76314 |       |         |       |
| B   | 6:00:10 | 72652 |    |         |       | R      | 2:31:49 | 76314 |       |         |       |
| B   | 6:00:10 | 72762 |    |         |       | R      | 2:32:04 | 76314 |       |         |       |

Table 12. Combat orders message summary.

| CASE<br>TIME | I  |    | II |     | III |    | IV |     | III-IP |    | IV-IP |     |
|--------------|----|----|----|-----|-----|----|----|-----|--------|----|-------|-----|
|              | #  | t  | #  | t   | #   | t  | #  | t   | #      | t  | #     | t   |
| :30          | 21 | 27 | 13 | 135 | 21  | 27 | 13 | 135 | 21     | 27 | 13    | 135 |
| 1:00         | 0  | -  | 8  | 121 | 0   | -  | 8  | 121 | 0      | -  | 8     | 121 |
| 1:30         | 0  | -  | 0  | -   | 0   | -  | 0  | -   | 0      | -  | 0     | -   |
| 2:00         | 5  | 15 | 3  | 97  | 5   | 37 | 5  | 59  | 5      | 28 | 3     | 90  |
| 2:30         | 7  | 18 | 24 | 357 | 7   | 38 | 12 | 251 | 7      | 37 | 17    | 291 |
| 3:00         | 5  | 17 | 1  | 215 | 0   | -  | 4  | 281 | 0      | -  | 1     | 867 |
| 3:30         | 0  | -  | 0  | -   | 0   | -  | 0  | -   | 0      | -  | 0     | -   |
| 4:00         | 0  | -  | 0  | -   | 4   | 78 | 0  | -   | 4      | 22 | 0     | -   |
| 4:30         | 4  | 23 | 0  | -   | 5   | 18 | 4  | 91  | 5      | 47 | 0     | -   |
| 5:00         | 5  | 21 | 2  | 237 | 5   | 17 | 4  | 69  | 5      | 19 | 2     | 146 |
| 5:30         | 12 | 48 | 8  | 106 | 7   | 33 | 13 | 90  | 7      | 18 | 15    | 160 |
| 6:00         | 0  | -  | 3  | 527 | 0   | -  | 0  | -   | 0      | -  | 0     | -   |
| 6:30         | 0  | -  | 4  | 198 | 0   | -  | 0  | -   | 0      | -  | 0     | -   |
| 7:00         | 0  | -  | 0  | -   | 4   | 56 | 0  | -   | 0      | -  | 0     | -   |
| 7:30         | 0  | -  | 3  | 77  | 0   | -  | 0  | -   | 4      | 88 | 4     | 370 |
| 8:00         | 0  | -  | 0  | -   | 0   | -  | 0  | -   | 0      | -  | 0     | -   |
| 8:30         | 4  | 20 | 0  | -   | 0   | -  | 0  | -   | 0      | -  | 0     | -   |

t is in seconds

Table 13. Status report message summary.

|       | t  | II        |     | III       |    | IV        |     | III IF    |    | IV IF     |     |
|-------|----|-----------|-----|-----------|----|-----------|-----|-----------|----|-----------|-----|
|       |    | $\bar{t}$ | n   | $\bar{t}$ | n  | $\bar{t}$ | n   | $\bar{t}$ | n  | $\bar{t}$ | n   |
| 3.00  | 19 | 0         | 0   | -         | 0  | -         | 0   | -         | 0  | -         | 0   |
| 4.00  | 19 | 139       | 38  | 26.6      | 19 | 139       | 38  | 26.6      | 19 | 139       | 38  |
| 5.00  | 33 | 132       | 90  | 30.7      | 41 | 149       | 90  | 30.7      | 41 | 147       | 90  |
| 6.00  | 33 | 165       | 108 | 26.3      | 42 | 176       | 124 | 39.5      | 44 | 171       | 124 |
| 7.00  | 31 | 317       | 74  | 32.1      | 73 | 512       | 80  | 41.7      | 60 | 344       | 60  |
| 8.00  | 27 | 430       | 74  | 38.9      | 78 | 556       | 70  | 55.6      | 61 | 539       | 61  |
| 9.00  | 33 | 490       | 46  | 38.4      | 56 | 346       | 42  | 52.1      | 48 | 403       | 48  |
| 10.00 | 29 | 335       | 31  | 27.1      | 40 | 273       | 32  | 32.4      | 30 | 119       | 30  |
| 11.00 | 31 | 136       | 40  | 40.4      | 41 | 160       | 28  | 28.2      | 24 | 176       | 24  |
| 12.00 | 27 | 164       | 46  | 37.0      | 41 | 158       | 37  | 26.6      | 34 | 238       | 34  |
| 13.00 | 34 | 267       | 42  | 38.1      | 38 | 157       | 33  | 40.1      | 27 | 221       | 27  |
| 14.00 | 30 | 259       | 23  | 43.4      | 41 | 228       | 33  | 37.5      | 37 | 194       | 37  |
| 15.00 | 35 | 122       | 40  | 41.3      | 38 | 249       | 22  | 36.7      | 40 | 175       | 40  |
| 16.00 | 34 | 79        | 55  | 27.3      | 22 | 133       | 18  | 40.0      | 35 | 135       | 35  |
| 17.00 | 37 | 201       | 55  | 41.8      | 26 | 145       | 21  | 43.1      | 41 | 149       | 41  |
| 18.00 | 37 | 99        | 47  | 40.2      | 25 | 113       | 24  | 33.8      | 59 | 275       | 59  |
| 19.00 | 16 | 0         | 40  | 26.8      | 12 | 156       | 30  | 31.3      | 36 | 241       | 36  |

t is in seconds

Table 14. Artillery request message summary.

| Case<br>Time | I   |      | II  |      | III |      | IV  |     | III-IP |      | IV-IP |     |
|--------------|-----|------|-----|------|-----|------|-----|-----|--------|------|-------|-----|
|              | #   | t    | #   | t    | #   | t    | #   | t   | #      | t    | #     | t   |
| 1:30         | 0   | -    | 0   | -    | 0   | -    | 0   | -   | 0      | -    | 0     | -   |
| 1:00         | 265 | 31.4 | 39  | 96   | 278 | 30.6 | 39  | 96  | 278    | 30.6 | 39    | 96  |
| 1:30         | 674 | 34.0 | 210 | 648  | 844 | 31.4 | 205 | 641 | 844    | 31.4 | 198   | 669 |
| 2:00         | 621 | 32.9 | 639 | 849  | 898 | 35.0 | 684 | 881 | 926    | 38.5 | 671   | 883 |
| 2:30         | 322 | 36.0 | 757 | 861  | 539 | 36.6 | 767 | 904 | 604    | 45.8 | 674   | 898 |
| 3:00         | 229 | 38.4 | 378 | 889  | 531 | 33.0 | 406 | 909 | 456    | 38.1 | 302   | 829 |
| 3:30         | 307 | 34.3 | 236 | 559  | 361 | 37.0 | 287 | 679 | 208    | 44.8 | 134   | 553 |
| 4:00         | 115 | 36.0 | 296 | 744  | 164 | 41.6 | 243 | 658 | 182    | 47.4 | 202   | 594 |
| 4:30         | 117 | 35.4 | 239 | 781  | 180 | 40.4 | 189 | 482 | 190    | 39.9 | 141   | 440 |
| 5:00         | 116 | 34.7 | 252 | 1051 | 226 | 34.6 | 313 | 668 | 172    | 32.7 | 165   | 512 |
| 5:30         | 117 | 34.1 | 339 | 882  | 264 | 32.5 | 300 | 699 | 149    | 33.5 | 117   | 342 |
| 6:00         | 113 | 35.4 | 162 | 533  | 106 | 45.0 | 290 | 675 | 154    | 31.9 | 229   | 452 |
| 6:30         | 117 | 35.6 | 33  | 229  | 194 | 35.7 | 144 | 384 | 140    | 44.0 | 352   | 567 |
| 7:00         | 90  | 36.7 | 57  | 72   | 297 | 35.3 | 103 | 245 | 104    | 36.0 | 335   | 606 |
| 7:30         | 11  | 37.3 | 53  | 65   | 350 | 42.6 | 73  | 65  | 81     | 28.7 | 420   | 631 |
| 8:00         | 40  | 37.7 | 19  | 55   | 396 | 29.3 | 28  | 64  | 90     | 34.6 | 326   | 477 |
| 8:30         | 3   | 38.0 | 8   | 74   | 259 | 33.1 | 23  | 73  | 193    | 31.4 | 264   | 475 |

t is in seconds

Table 15. Intelligence report message summary.

| CASE<br>TIME | I  |           | II |           | III |           | IV |           | III-fp |           | IV-fp |           |
|--------------|----|-----------|----|-----------|-----|-----------|----|-----------|--------|-----------|-------|-----------|
|              | #  | $\bar{t}$ | #  | $\bar{t}$ | #   | $\bar{t}$ | #  | $\bar{t}$ | #      | $\bar{t}$ | #     | $\bar{t}$ |
| 0:30         | 0  | -         | 0  | -         | 0   | -         | 0  | -         | 0      | -         | 0     | -         |
| 1:00         | 9  | 29.0      | 11 | 138       | 15  | 28.0      | 11 | 138       | 15     | 28.0      | 11    | 138       |
| 1:30         | 28 | 37.6      | 18 | 188       | 42  | 28.2      | 23 | 180       | 42     | 28.2      | 20    | 149       |
| 2:00         | 30 | 34.7      | 18 | 374       | 38  | 52.5      | 27 | 402       | 38     | 30.7      | 16    | 551       |
| 2:30         | 14 | 20.4      | 16 | 475       | 15  | 44.8      | 23 | 406       | 26     | 39.1      | 15    | 442       |
| 3:00         | 15 | 39.9      | 11 | 345       | 19  | 44.8      | 18 | 323       | 18     | 36.6      | 11    | 341       |
| 3:30         | 17 | 34.4      | 8  | 389       | 19  | 37.5      | 18 | 437       | 9      | 29.2      | 12    | 312       |
| 4:00         | 12 | 35.0      | 14 | 200       | 10  | 29.6      | 11 | 289       | 10     | 54.4      | 10    | 149       |
| 4:30         | 9  | 38.0      | 11 | 414       | 7   | 58.0      | 18 | 466       | 15     | 41.7      | 8     | 163       |
| 5:00         | 21 | 36.6      | 15 | 307       | 11  | 37.8      | 13 | 231       | 8      | 35.0      | 4     | 167       |
| 5:30         | 10 | 26.2      | 2  | 225       | 8   | 56.5      | 14 | 146       | 6      | 12.7      | 8     | 263       |
| 6:00         | 6  | 15.5      | 4  | 98        | 7   | 49.3      | 14 | 156       | 6      | 26.5      | 16    | 140       |
| 6:30         | 5  | 51.8      | 7  | 207       | 5   | 49.4      | 9  | 190       | 7      | 33.7      | 16    | 283       |
| 7:00         | 4  | 24.0      | 5  | 161       | 6   | 15.8      | 4  | 165       | 5      | 38.6      | 22    | 236       |
| 7:30         | 3  | 20.0      | 4  | 115       | 9   | 28.3      | 5  | 128       | 3      | 66.0      | 6     | 207       |
| 8:00         | 2  | 10.0      | 0  | -         | 7   | 30.1      | 2  | 64        | 1      | 10.0      | 11    | 268       |
| 8:30         | 1  | 32.0      | 0  | -         | 6   | 86.0      | 2  | 54        | 5      | 65.4      | 10    | 136       |

$\bar{t}$  is in seconds

Table 16. Aggregate communications performance summary by case and message type at 0830.

| CASE   | ORDERS |      | STATUS RPTS |      | ARTY REQ |      | INTELL RPTS |      | TOTAL |      |
|--------|--------|------|-------------|------|----------|------|-------------|------|-------|------|
|        | #      | t    | #           | t    | #        | t    | #           | t    |       | t    |
| I      | 63     | 27.2 | 579         | 30.6 | 3615     | 34.1 | 177         | 33.4 | 4443  | 33.5 |
| II     | 69     | 228  | 617         | 281  | 4050     | 792  | 144         | 239  | 4880  | 705  |
| III    | 58     | 33.9 | 846         | 33.9 | 5782     | 34.1 | 224         | 40.5 | 6910  | 34.3 |
| IV     | 63     | 142  | 633         | 279  | 4094     | 720  | 212         | 290  | 5002  | 639  |
| III-FP | 58     | 32.2 | 722         | 35.4 | 4681     | 37.3 | 214         | 34.4 | 5675  | 37.0 |
| IV-FP  | 63     | 206  | 636         | 248  | 4684     | 659  | 206         | 252  | 5589  | 592  |

t is in seconds



twice an order-of-magnitude increase for artillery requests when communications is degraded. There are so many artillery requests relative to the other message categories that the "twice an order of magnitude" effect dominates in the "total" column. The second feature is the more consistent message completion rate in the nuclear free-play cases (III-FP and IV-FP). The implication is that while communications experience large time delays, the messages eventually do go through (only 1.5 percent fewer total messages completed in the degraded communications case). Although there is a decrease in both intelligence and status reports in the degraded communications case, this has little effect on the battle because of the rudimentary automated command, control, and intelligence fusion processes in the model.

A graphic display of the communications time delay due to degradation can be developed by accumulating the number of messages completed with increasing time for each of the six cases and comparing the resulting functions in nondegraded and degraded pairs. The three resulting pairs for the six TRACE cases are shown in Figures 24, 25, and 26, respectively.

Case II appears to be the least satisfactory result from a purely intuitive standpoint. Under conditions of degraded communications performance, we see more successful communications taking place after about four and one-half hours and only moderate time delay before that. Implicitly, there are more messages generated in the degraded versus the non-degraded case because not all messages generated were completed and yet all those that were completed are shown in the figure. This result is due in part to the different response of the MITL in Case II wherein a larger number of the Blue combat units engaged in conflict earlier and survived combat longer and thus were able to generate more message traffic over time.

Cases III and IV, on the other hand, show a more intuitive result but should not be arbitrarily accepted as "the truth" on that basis. Two key factors pertaining to these cases must be considered. First, these are the third and fourth times the MITL has seen and played the same basic situation which must have an effect on his objectivity and, secondly, an undiscovered problem caused inappropriate utilization of the tactical

nuclear weapons. (Even the automated Red usage seems strange although it could be perfectly correct based on the model criteria for use of nuclear weapons.)

The relationship between Cases III-FP and IV-FP speaks for itself and is entirely consistent with no MITL intervention as well as the utilization of both Red and Blue nuclear resources.

#### 5.6 LOSS EXCHANGE RATIOS

From the resources remaining data presented in Tables 6 and 7 in Section 5.2, we can develop loss exchange ratios (LER). Those ratios, representing Red unit losses per unit Blue loss, are presented in Table 17 below for both 05:30 and 08:30.

Table 17. Combat resource loss exchange ratio summary.

| Case   | 05:30 |       |      |      | 08:30 |       |      |      |
|--------|-------|-------|------|------|-------|-------|------|------|
|        | Inf   | Armor | Arty | Ammo | Inf   | Armor | Arty | Ammo |
| I      | 2.64  | 1.05  | 0    | 1.04 | 2.86  | 1.01  | 0    | 1.12 |
| II     | 1.69  | 1.19  | .08  | 1.00 | 2.05  | 1.19  | .20  | 1.02 |
| III    | 2.31  | 1.39  | .07  | 1.28 | 2.46  | 1.82  | .06  | 1.12 |
| IV     | 2.60  | 1.55  | .19  | 1.13 | 2.46  | 1.52  | .15  | 1.08 |
| III-FP | 3.39  | 1.60  | .42  | 1.07 | 2.83  | 1.74  | 0    | 1.13 |
| IV-FP  | 1.94  | 1.34  | .59  | 1.19 | 1.70  | 1.63  | .28  | 1.14 |

We are now in a position to make a comparison between the degraded and non-degraded communications cases. On the premise that degraded Blue communications results in poorer or smaller loss exchange ratios, we can take the quotient of the LER for non-degraded communications divided by the LER for degraded communications as a measure of communications effectiveness. These quotients are presented in Table 18 below.

Table 18. Non-degraded to degraded communications LER ratios.

| Case         | 05:30 |       |      |      | 08:30 |       |      |      |
|--------------|-------|-------|------|------|-------|-------|------|------|
|              | Inf   | Armor | Arty | Ammo | Inf   | Armor | Arty | Ammo |
| Conventional | 1.56  | .88   | 0    | 1.03 | 1.40  | .85   | 0    | 1.10 |
| Nuclear      | .89   | .90   | .39  | 1.13 | 1.00  | 1.20  | .41  | 1.03 |
| Nuclear F.P. | 1.75  | 1.20  | .72  | .90  | 1.67  | 1.07  | 0    | .99  |

An interesting graphic representation of the data in Table 18 is obtained by subtracting one (1.0) from each LER ratio and forming a bar-type chart. This results in a chart where positive values imply benefits of good communications while negative values imply detriments of communications (or advantages of degraded communications). The two charts for 05:30 and 08:30 are shown in Figures 27 and 28 respectively.

Artillery tubes appear to suffer so badly that the LER ratios cannot be conveniently included in the figures. In actuality, we have a numerical quirk due to the loss of very few or no Red artillery tubes as shown in Table 7. In general, however, Blue artillery losses are less under degraded communications conditions because they do not advance as quickly toward the enemy thereby lessening their vulnerability.

The fact that communications had little or no measurable effect on some of the LERs is not directly explicable but there are three known factors influencing this result. The first is quite simply that the course of the battle was influenced heavily by the Blue (MITL) Division Commander who became a little more aggressive in Cases III and IV due to familiarity with the Red attack and his ability to employ tactical nuclear weapons. Secondly, the nuclear weapons themselves were employed in a manner that led to significant self-inflicted damages. In all cases, Blue damages due to Blue strikes occurred to Blue units that for the most part had been already neutralized by the enemy but were far from dead. And finally, Blue attempted to employ his six remaining tactical nuclear weapons in Case IV

at 06:00 hours but they failed to detonate in the TRACE model. Unfortunately, there was insufficient time to isolate the problem, solve it, and rerun the Case. We notice, however, that in response, Red did not use all of his nuclear weapons which mitigates the severity of this error.

#### 5.7 GROUND EXCHANGE

Up to this point, we have considered several factors and numerical quantifications characterizing various aspects of the conflict progress and outcome. None of these, however, taken alone or in combination reflect the key issue under contention by the combatants which, in the TRACE scenario, is the control of terrain. From the Blue player's point-of-view, the objective is to successfully defend a phaseline until a specified time and retain control of the area behind that line. Red, on the other hand, wishes to attack, penetrate, gain control of, and reduce or eliminate any threat of the loss of that same piece of terrain. Both sides would ideally like to accomplish their respective missions with a minimum loss of their own resources, particularly personnel.

The scenario used and the graphics generation capability of TRACE readily permitted a determination of the terrain exchange for each of the six cases examined. The positions of all combatant units (not dead or neutralized) were plotted by computer on standard printer paper output medium using letter symbols for Blue players and numbers for Red. These "position maps" were generated at 30-minute intervals throughout the battle and are included in this report in Appendices F through K for Cases I through IV-FP, respectively. Because there is no automated procedure for determining the terrain occupied and controlled by either combatant's forces, three time-points were selected for manual evaluation. These were 0230, 0530, and 0830 corresponding to two combat phases and the end of the conflict scenario. This decision resulted in 18 position maps (three each for six cases) that were evaluated to determine the terrain exchange quantification. The exact procedure used is presented in Appendix L as well as the 18 subject position maps while the results are summarized in Table 19 below.

Table 19. Terrain lost by Blue side at 0230, 0530, and 0830 in square kilometers.

| Case   | Time |      |      |
|--------|------|------|------|
|        | 0230 | 0530 | 0830 |
| I      | 60.1 | 68.4 | 64.5 |
| II     | 61.3 | 65.5 | 66.0 |
| III    | 48.3 | 59.4 | 73.9 |
| IV     | 53.8 | 53.9 | 51.7 |
| III-FP | 40.7 | 62.2 | 78.9 |
| IV-FP  | 45.0 | 76.5 | 89.8 |

The data in Table 19 becomes more meaningful if we compare the non-degraded and degraded communications cases via a ratio such that a positive value implies the benefit of unimpaired communications. Those ratios are shown in Table 20 below.

Table 20. Degraded to non-degraded communications terrain exchange comparisons.

| Case Ratio     | Time  |       |        |
|----------------|-------|-------|--------|
|                | 0230  | 0530  | 0830   |
| II : I         | 2.0%  | -4.2% | 2.3%   |
| IV : III       | 11.4% | -9.3% | -30.0% |
| IV-FP : III-FP | 10.6% | 23.0% | 13.8%  |

Referring to the table, it becomes immediately clear that only the free-play cases follow our intuitive expectations. That is, comparing the two FP cases, Blue loses more terrain in the degraded communications case consistently. We note also that the advantage of good communications is less significant at battle's end than it was during the first five and one-half hours of the conflict.

The Case IV to Case III comparison strongly suggests that Blue is much better off with degraded communications! Notice also that the value of communications consistently deteriorates as the battle progresses. One factor strongly influencing this rather disturbing result is the complete familiarity of the MITL with the scenario as well as his awareness of how well (or poorly) he did in previous cases. His displayed aggressiveness in Case IV indicated his desire to "win" (military roots) and he definitely lost some of his objectivity with respect to the study objectives. Secondly, we recall that the nuclear weapons-play in Case IV was not correct per the MITL's directives and this undoubtedly influences the result although we don't know exactly how or the extent to which it does. Little can be said with respect to the comparisons of Cases I and II that would be substantive. The general conclusion would be, of course, that communication didn't make a significant difference and, that after 0230 hours, the battle was for the most part, a standoff. An interesting feature, however, is the fact that Red was able to gain more territory in Case III than in either Case I or II.

#### 5.8 SUMMARY

We have explored several parameters relating to and characterizing the status of the conflict engagement at selected time-points during the battle. None of these alone give us adequate insight into the value of communications other than to say that good communications generally appears to a favorable factor. In order to make a numerically meaningful comparison of the degraded and non-degraded communications cases, we need a measure of the outcome of each case that encompasses all of the key individual factors characterizing that case.

The data presented in Tables 6, 7, and 8 can be combined and transformed into a single table of combat losses which we have presented in Table 21 for the convenience of the reader. Consider the Blue player's point-of-view; he wants to defend his own initial ground, inflict losses to his opponent's resources, and minimize his own losses to the opponent. It seems reasonable then that a measure of success from Blue's point-of-view

Table 21. Combat losses of both players at the end of conflict (0830).

| Case   | Blue |       |      |        |        | Red |       |      |        |
|--------|------|-------|------|--------|--------|-----|-------|------|--------|
|        | Inf  | Armor | Arty | Ammo   | Ground | Inf | Armor | Arty | Ammo   |
| I      | 50   | 124   | 9    | 42,694 | 64.5   | 83  | 97    | 0    | 28,490 |
| II     | 53   | 118   | 23   | 45,997 | 66.0   | 63  | 109   | 5    | 27,904 |
| III    | 75   | 98    | 31   | 41,560 | 73.9   | 107 | 139   | 2    | 27,670 |
| IV     | 61   | 143   | 19   | 43,088 | 51.7   | 87  | 169   | 3    | 27,758 |
| III-FP | 70   | 119   | 29   | 38,109 | 78.9   | 115 | 161   | 0    | 25,589 |
| IV-FP  | 69   | 123   | 23   | 37,715 | 89.8   | 68  | 156   | 7    | 25,501 |

would minimize his resource and territory losses and maximize his opponent's resource losses. That premise leads to a payoff parameter (P) that takes the form of Red losses per Blue resource loss per defense area loss, i.e.,

$$P = \frac{\text{Red resources lost}}{(\text{Blue resources lost})(\text{Blue ground lost})}$$

The loss of infantry units, armor units, and artillery units is directly related to personnel loss (or vice versa) whereas ammunition expenditure is less directly relatable. Because of this and the very small differences of ammunition expenditure in the paired cases, we will exclude ammunition from the analysis. The data in Table 21 then reduces to that shown in Table 22.

Table 22. Aggregated combat losses at 0830.

| Case   | Blue               |        | Red                |
|--------|--------------------|--------|--------------------|
|        | Inf + Armor + Arty | Ground | Inf + Armor + Arty |
| I      | 183                | 64.5   | 180                |
| II     | 194                | 66.0   | 177                |
| III    | 204                | 73.9   | 248                |
| IV     | 223                | 51.7   | 259                |
| III-FP | 218                | 78.9   | 276                |
| IV-FP  | 215                | 89.8   | 231                |

From the data in Table 22, we can now directly calculate the value of the payoff parameter  $P$  given in the equation above. The absolute value of  $P$  is not our ultimate goal however, but rather the effect that communications has on  $P$ . Assuming that better communication performance yields a greater payoff, we divide the non-degraded communications case payoff by the degraded communications case payoff. These payoff values and their ratios are summarized in Table 23.

Table 23. Case payoff parameters and comparisons.

| Case   | Payoff | Ratio |
|--------|--------|-------|
| I      | .0152  | 1.103 |
| II     | .0138  |       |
| III    | .0165  | .732  |
| IV     | .0225  |       |
| III-FP | .0160  | 1.341 |
| IV-FP  | .0120  |       |

The table reveals a 10 percent better payoff with undegraded communications for conventional warfare and a 34 percent better payoff in nuclear free



play. The nuclear MITL cases continue to show the reverse result as we discovered and discussed in the earlier sections.

The nuclear free-play assessment is a very pleasing result as it tends to show numerically, that communications does play a major and significant role in effective combat operations. We must carefully avoid unwarranted acceptance, however, of the absolute magnitude of these numbers. This caveat can surely be mitigated through additional refinement of and exploration with the TRACE model.

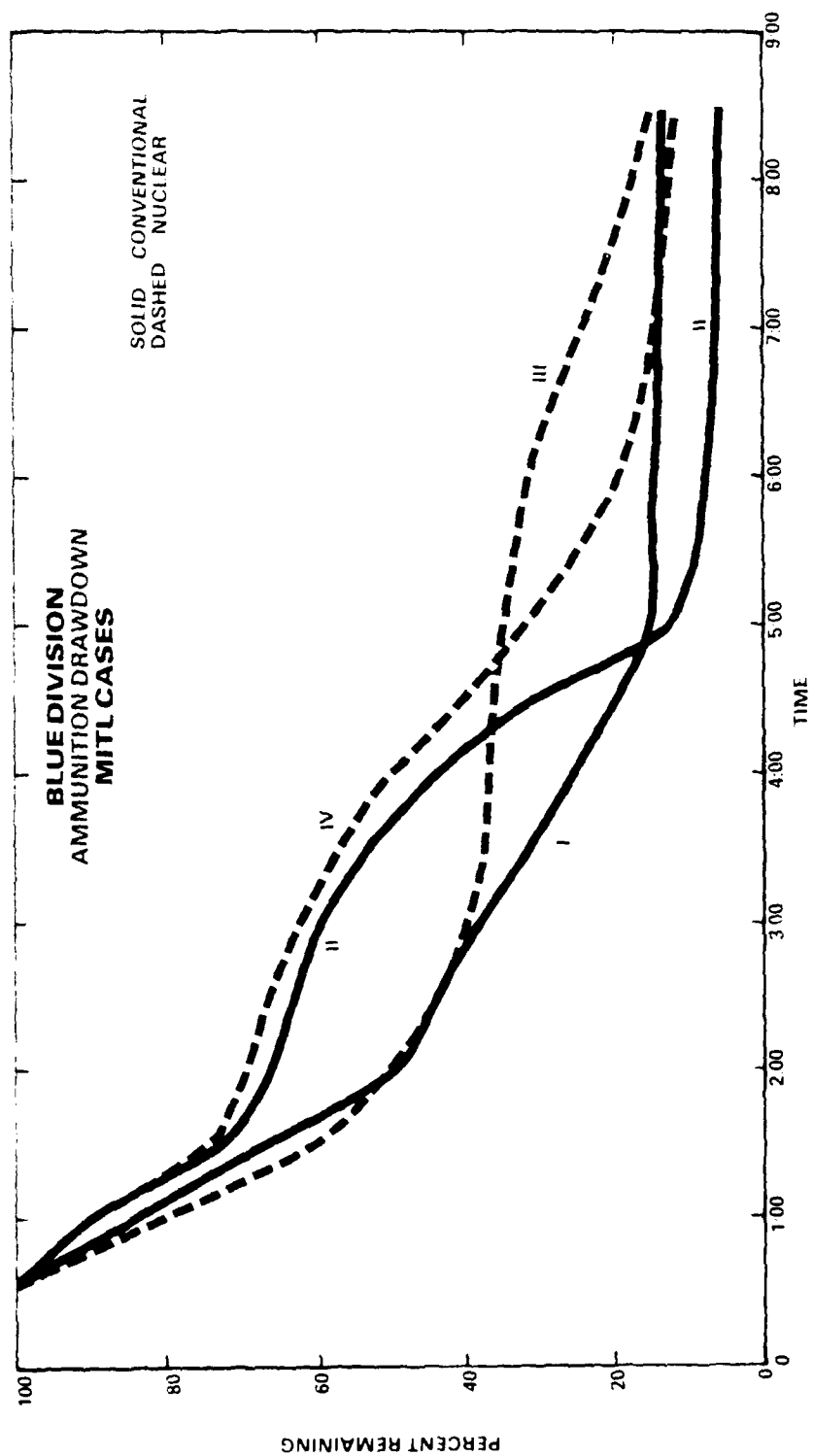


Figure 13. Blue division ammunition drawdown in the four MITL cases.

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DEVELOPMENT AND IMPLEMENTATION OF TCOR COMMO.(U)  
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BDM/W-80-055-TR

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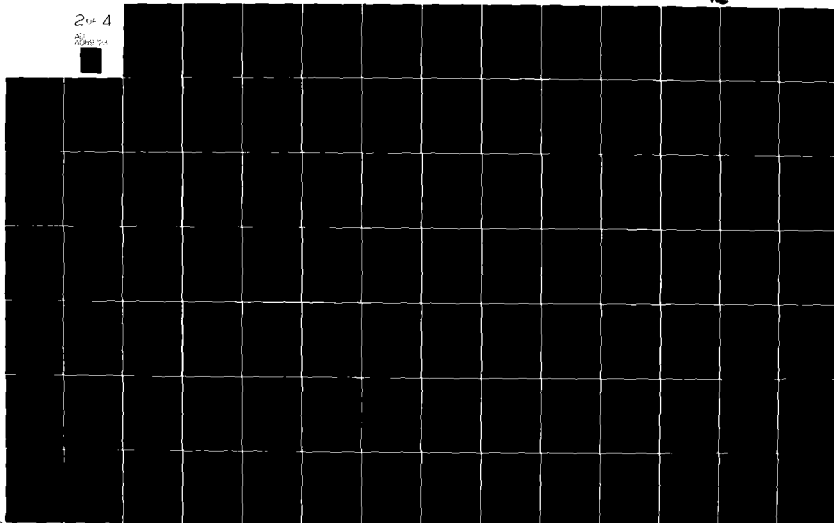
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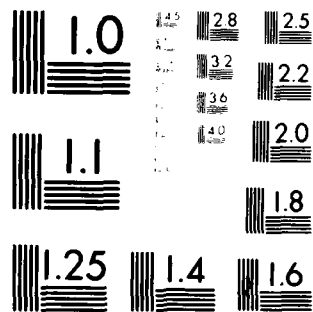
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NL

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MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

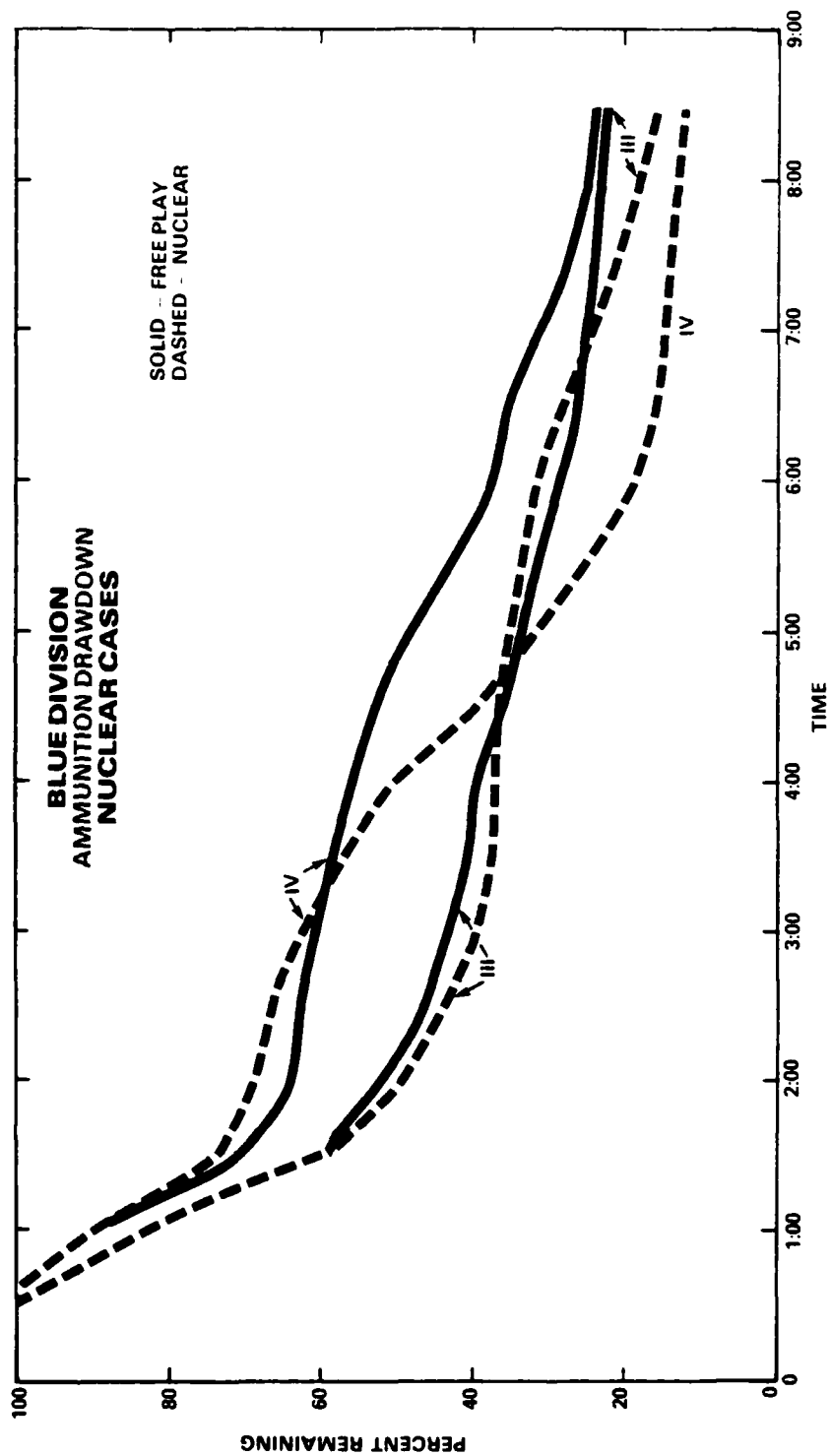


Figure 19. Blue division ammunition drawdown in the four nuclear cases.

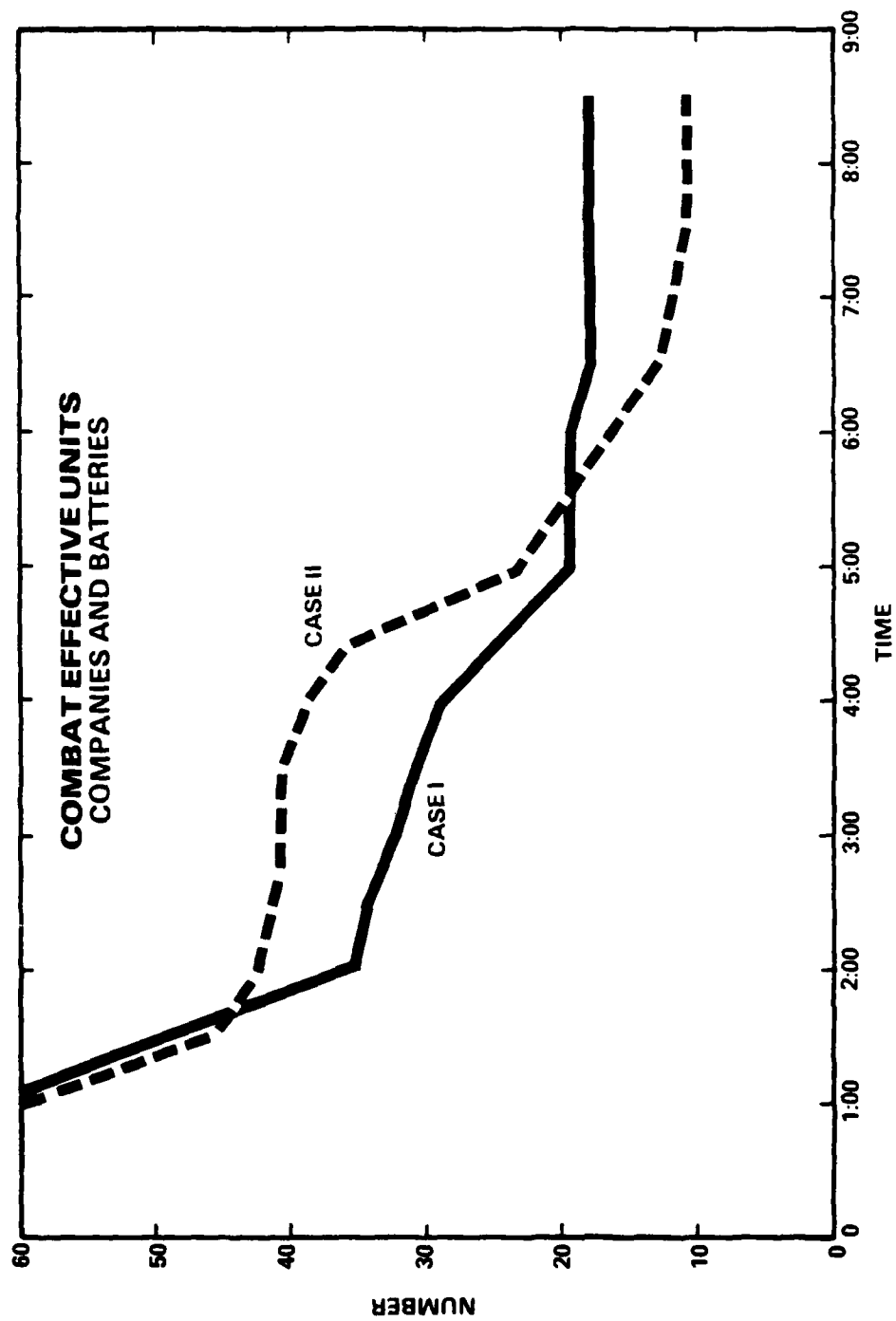


Figure 20. Combat effective units, companies and batteries.

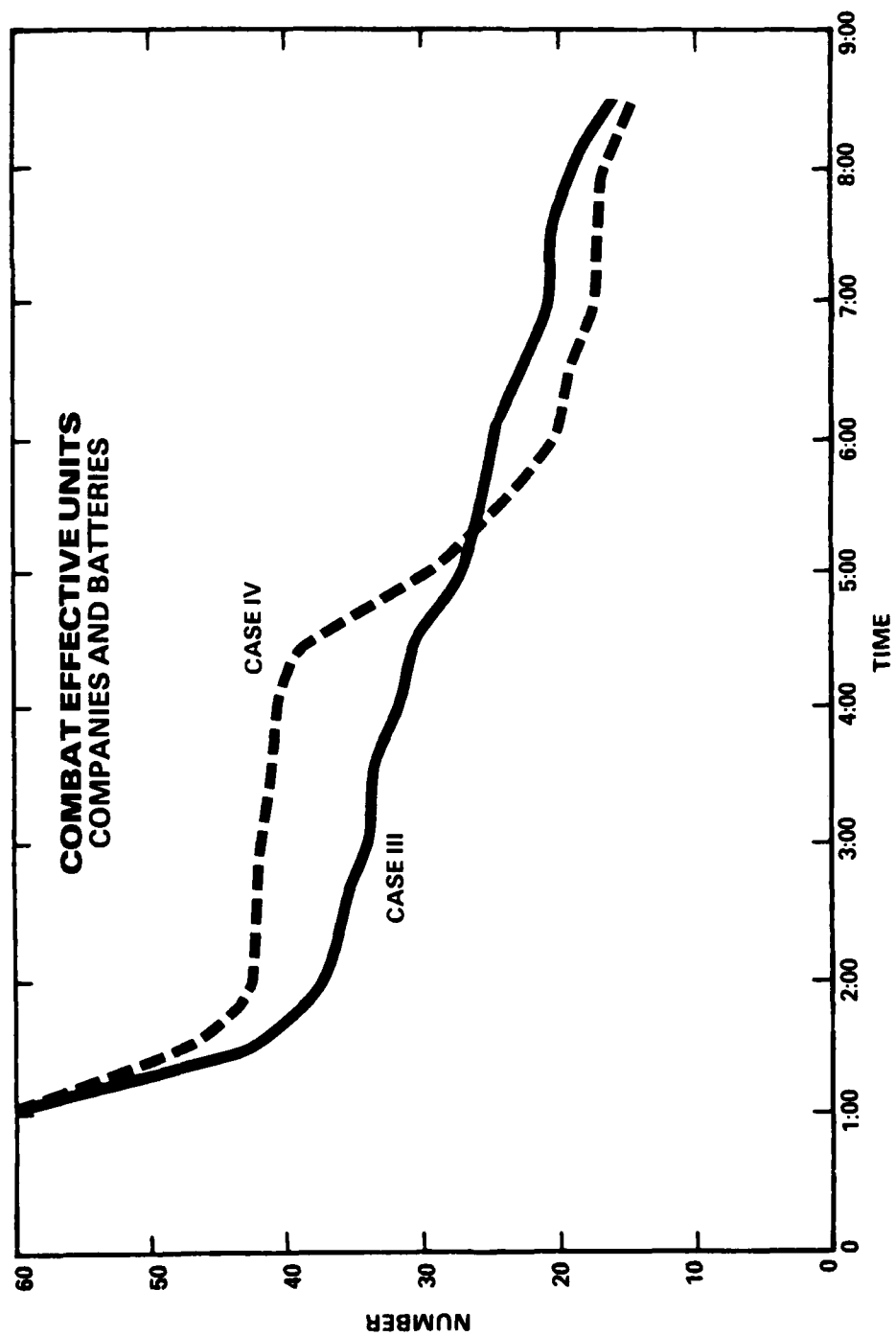


Figure 21. Combat effective units, companies and batteries.

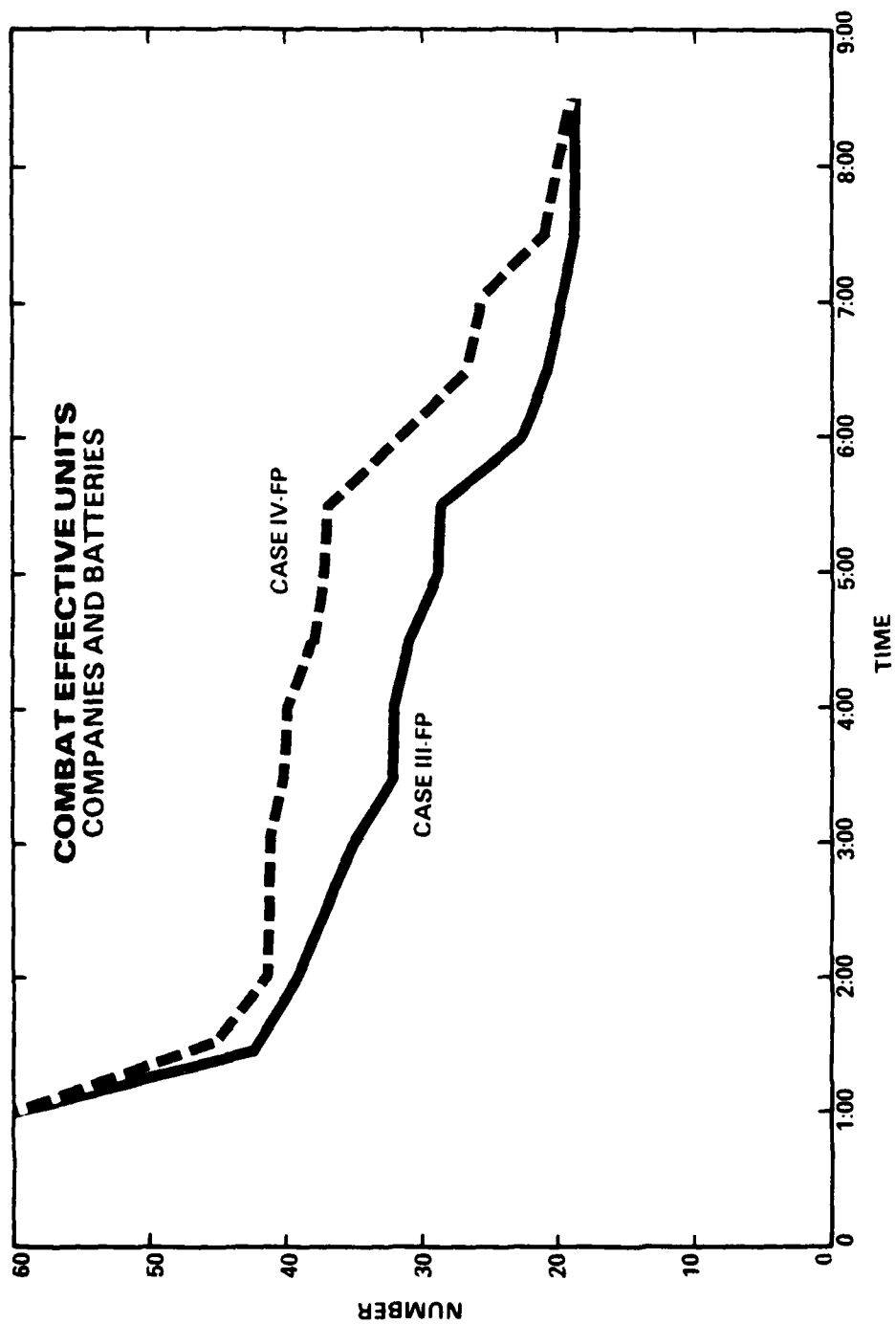
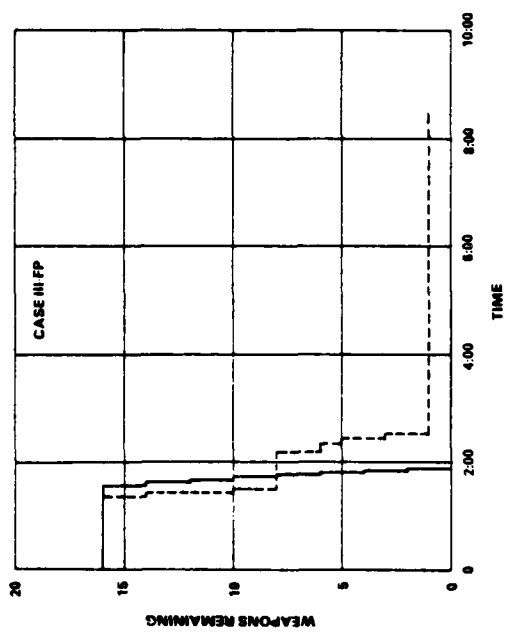


Figure 22. Combat effective units, companies and batteries.





Solid (—) : Blue  
Dashed (---) : Red

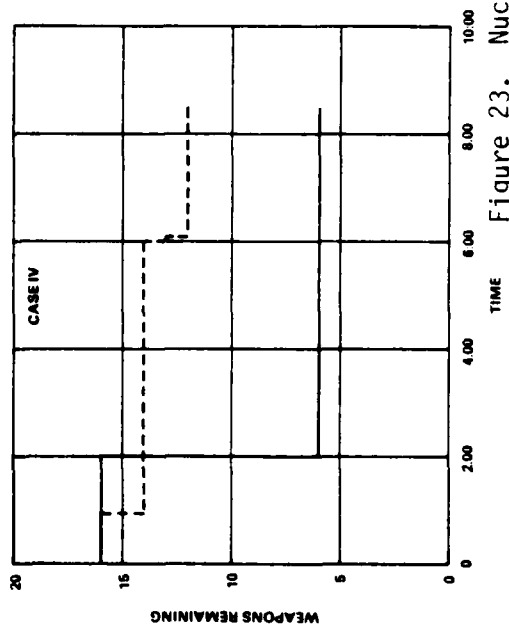
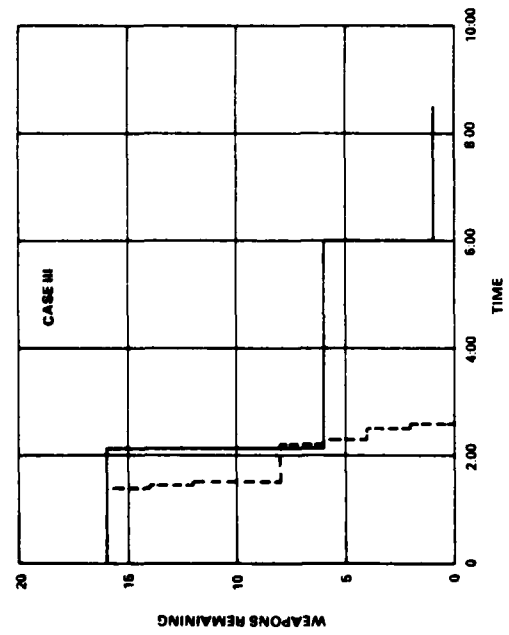
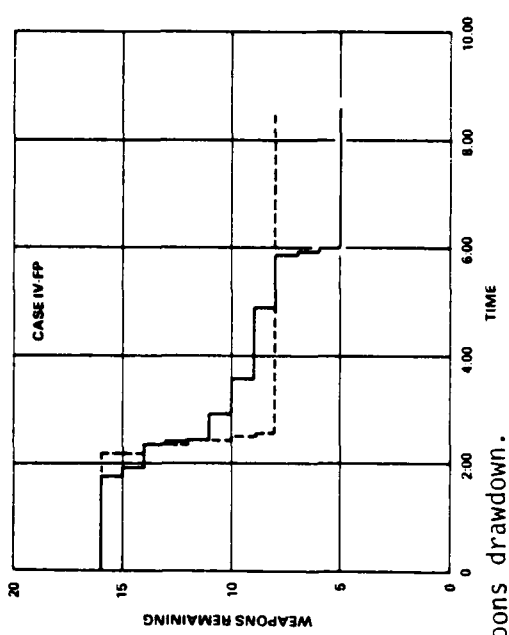


Figure 23. Nuclear weapons drawdown.

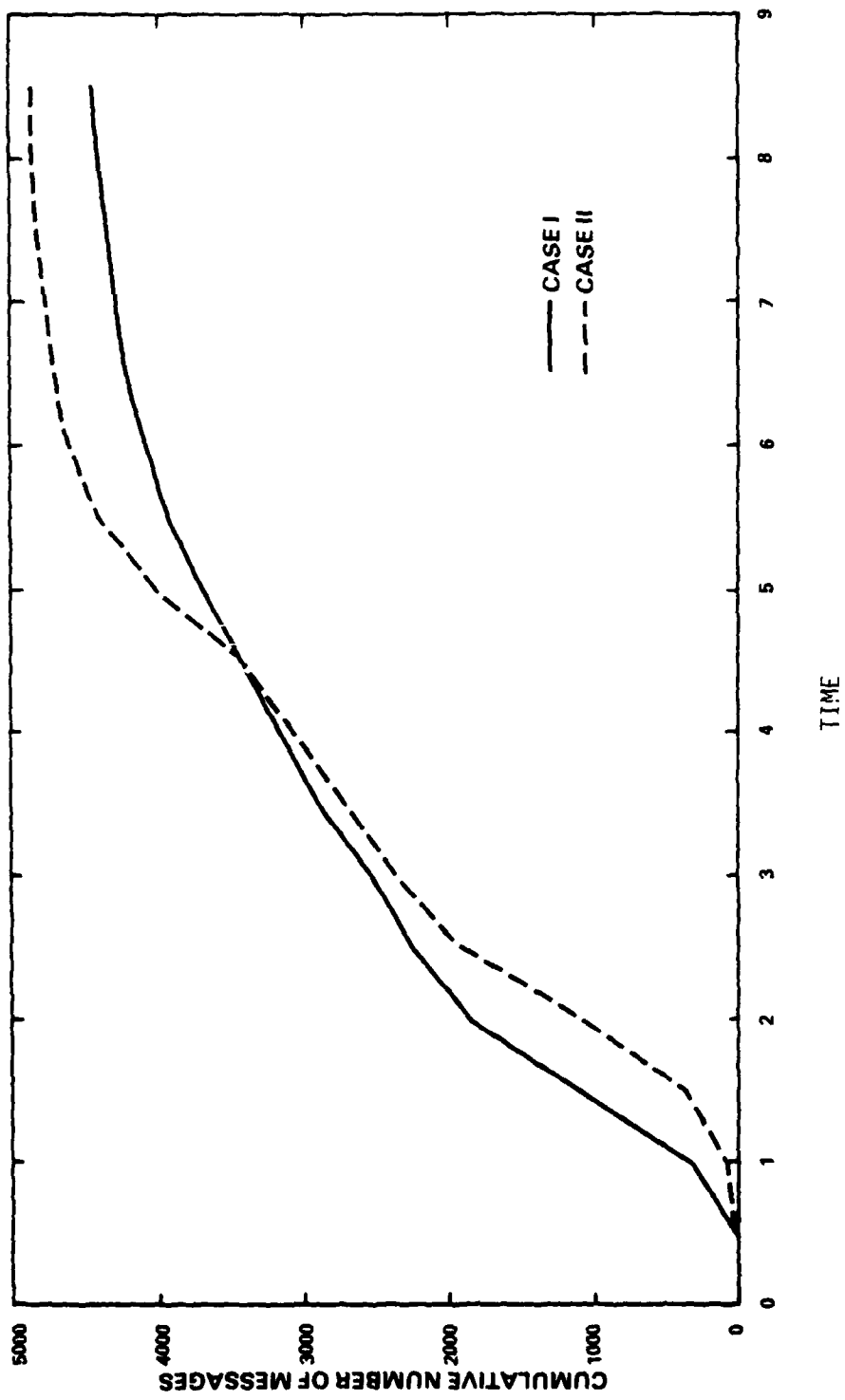


Figure 24. Cumulative message completion versus time for conventional warfare cases.

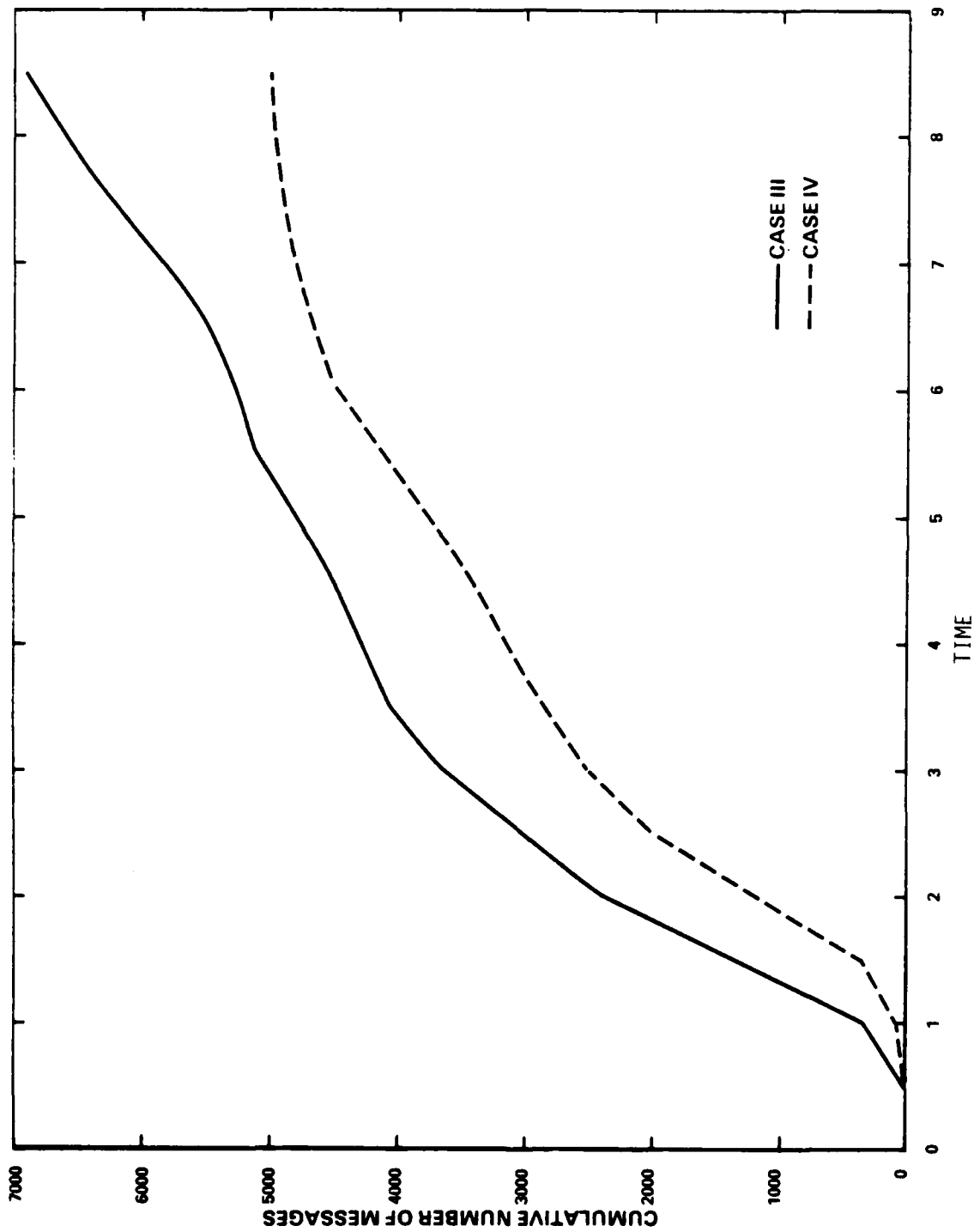


Figure 25. Cumulative message completions versus time for mixed warfare MITL cases.

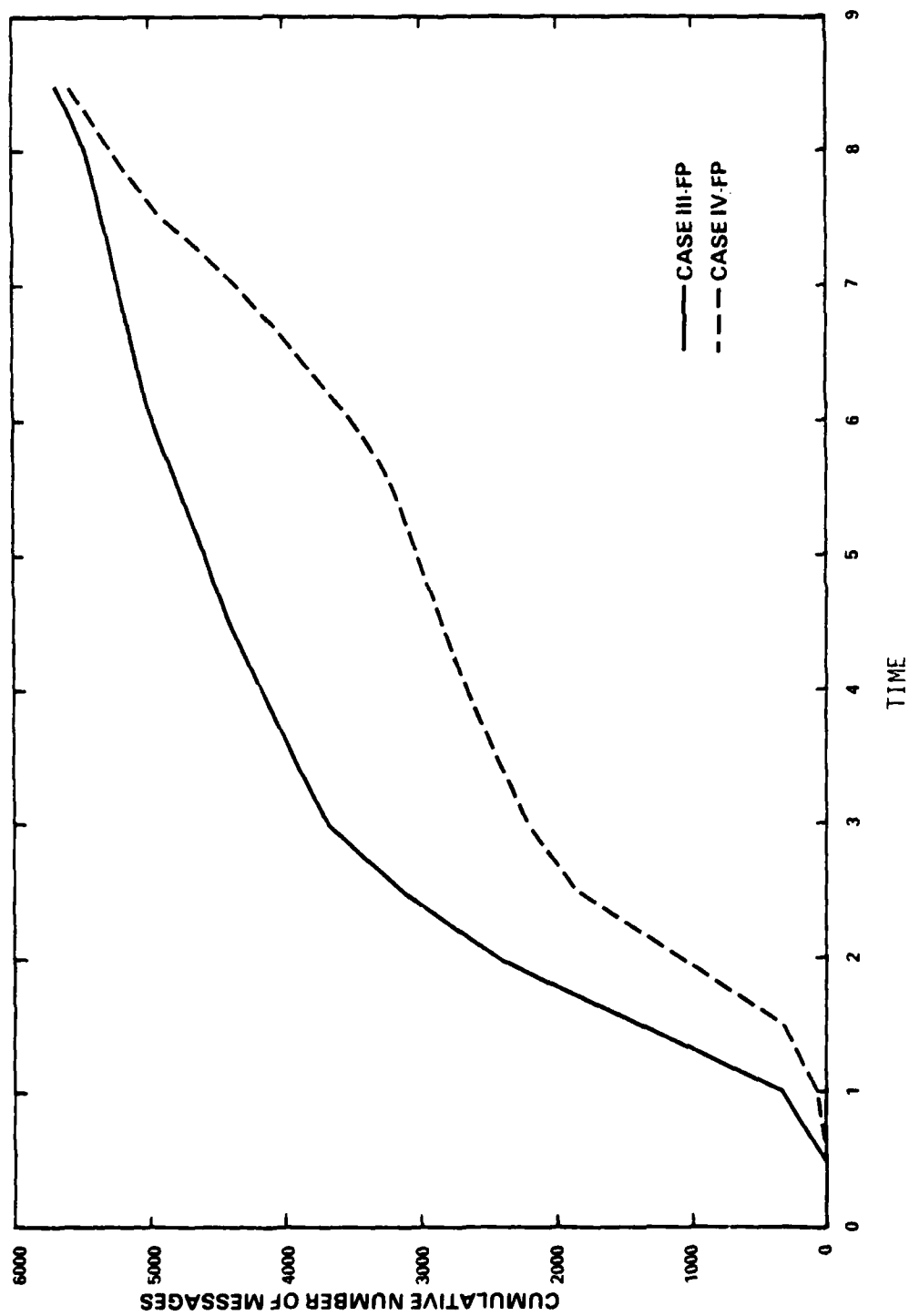


Figure 26. Cumulative message completions versus time for mixed warfare free-play cases.

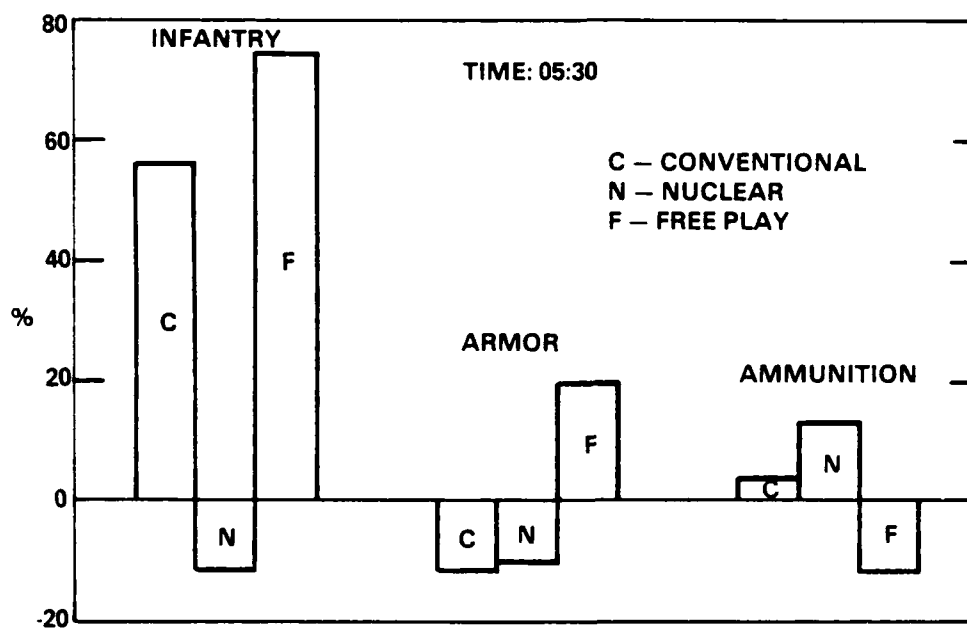


Figure 27. Degraded and non-degraded communications loss exchange ratio comparisons at 0530.

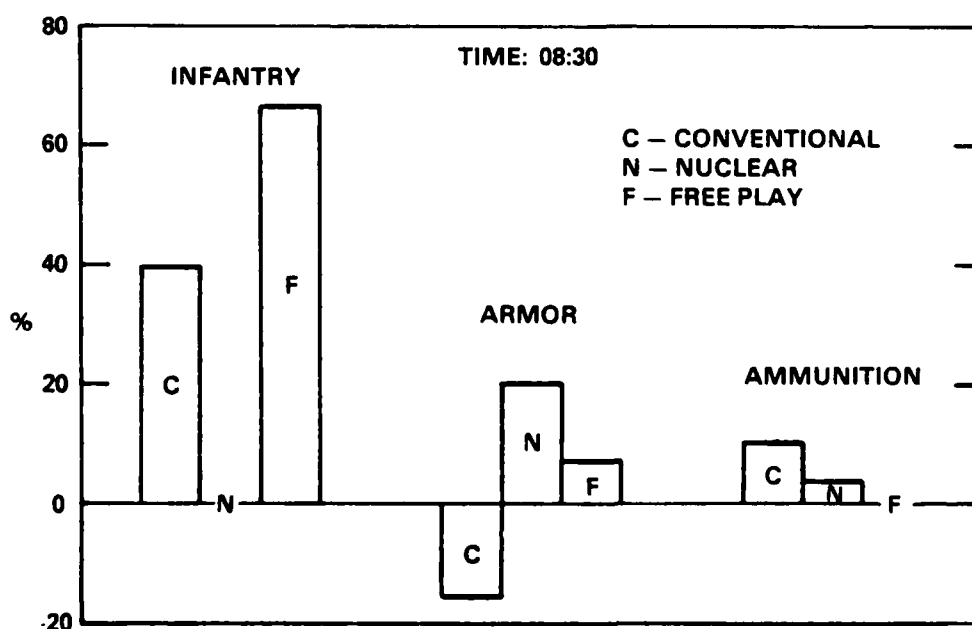


Figure 28. Degraded and non-degraded communications loss exchange ratio comparisons at 0830.

## SECTION 6

### CONCLUSIONS AND RECOMMENDATIONS

#### 6.1 CONCLUSIONS

This study began with the hypothesis that communications aids performance on the battlefield. The study results did not support this hypothesis in a statistically significant way. Assuming we can have some confidence in the case results, results from Section 5 show an improvement of +10.3%, -26.8%, and +34.1% for the three comparison sets conventional, nuclear, and nuclear FP. This gives a mean benefit of +5.9%. Assuming that the benefit of unimpaired communications is normally distributed about the true mean benefit, then it can be said that we are 90% confident that the true mean benefit is between +47.8% and -36.0%, a spread of 83.8%!

Statistically speaking, however, no confidence can be assigned to the values from each comparison for several reasons. The total freedom given the human MITL was too large a parametric variation to consider the compared cases to be simulating the same thing. Intuitively, the only change was the ability to degrade the communications. Statistically, the cases were not independent. Because the perfect communications case was performed first, the MITL gained maximum knowledge of the future in the degraded communications case immediately following. The more the MITL learned or remembered, the more independent of the communications he became. In fact, in one instance, the MITL responded to his briefing that he wanted to issue the same orders he had at this time in the last case. Some learning was expected but the similarity of the cases brought this learning to almost a predictive state. Also, in every case only one simulation was run. The model uses a pseudo-random number generator. The generator produces a stream of numbers, more than needed in a single run, in a sufficiently random pattern. It is not unusual for the same simulation to produce a small number of extreme results by changing the starting point in the generator's stream of numbers. In this study, no repetitive runs were made to test for extremities. In fact, it may have been

impossible to run replications because of the uncontrollable, unquantifiable learning by the MITL. To some degree he learned what to expect from the Red attack. (It was felt that changing the Red attack would make the cases too different to compare.)

From looking at the unit locations on the maps one can see that the Blue units are more flexible and responsive in the cases where communications was not degraded. The Blue forces tend to be more sluggish in the other cases, being met by Red forces instead of meeting them. Enemy/unit location on the briefing maps that were shown to the MITL averaged 27 minutes out of date for frontline Red forces in the nondegraded cases. (These maps were acetate overlays, not suitable for reproduction, and are not shown in this report.) In the degraded cases the information averaged over an hour out of date. Thus, whether the MITL was a good commander or a poor one, the information he had to work with was more up-to-date with nondegraded communications. In a subjective (nonstatistical) sense, one can see that communications degradation did make a difference. The amount of difference is obscured by various factors, some of them the same ones that prevented statistical validation:

- (1) MITL inexperience (as a MITL), learning, and variance
- (2) Undetermined utility/appropriateness of orders and support requests
- (3) Lack of an adequate number of comparable cases
- (4) Lack of decisive battlefield outcome for either Red or Blue in any of the cases
- (5) Unquantified degree of degradation to be used as a weighting factor in the case value parameter.

## 6.2 RECOMMENDATIONS

This study has shown that improved communications has a measurable effect on the progress of the battle and the  $C^2$  capabilities of the commanders. It gave evidence that good communications acts as a force multiplier but did not produce sufficient statistically sound data to measure this multiplier. It did point out the interfering conditions and the path to parameterizing most of them. Hence, this type of analysis shows promise for isolating and measuring the force multiplier.

Further study should now follow two different directions. Though, when explained, these may seem to be opposite directions, they are not mutually exclusive and should be considered together. The first direction is a proper simulation study totally excluding human induced variance. This requires that the  $C^3I$  functions be totally automated. It also requires acceptance of the belief that artificial intelligence (AI) can reasonably reproduce the  $C^2$  thought processes. The Operations Reaction System (ORS) is a  $C^2$  AI system developed by BDM for DNA-TCOR. (ORS was developed after the completion of the TRACE development.) The ORS is a good initial cut at fully automated  $C^2$  but it still reacts primarily to immediate stimuli. It has a beginning awareness of its battlefield environment (e.g., is a unit being flanked) but as yet has no awareness of its history (e.g., 50% losses in last 5 minutes and 50% in last 3 days are indistinguishable) or ability to plan/replan based on the situation. These deficiencies would have to be corrected before it would be suitable for this direction of study. Once a suitable  $C^2$  AI system is placed into a model like TRACE, autoregressive analysis can be used over a number of sets at similar cases where each set has a number of runs in it sufficient for statistically sound results. Degradation of communications could then be quantified and tests made to determine the distribution of the communications force multiplier.

The second direction is the gaming approach. This approach does not require belief in the ability of AI techniques. A group of MITLs is selected. (The exact number of them will depend on the sampling technique chosen for the statistical analysis). Each should have experience as a line officer in ground combat situations. Each is trained on a few test cases so they are familiar with the behavior of their simulated commands. Each is then the MITL for about 30 cases -- sufficient number to make small samples techniques applicable. These cases should have varying Red attacks and controlled, varying communications degradation. Mean results can be determined across a MITL's group of cases. By an extension of the Central Limit Theorem, it is known that these means are normally distributed. This facilitates meaningful statistical analysis of the crosscorrelations of



the degradation parametric variations in a commander's ability to perform his function. In this way, the force multipliers can be indirectly measured.

## SECTION 7

### REFERENCES

1. Statement of Work For Contract DNA001-78-C-0175 "Development and Implementation of TCOR COMMO."
2. "TRACE Computer Model User's Guide", BDM/W-78-776-TR, 12 October 1978.
3. FM 105-5 "Maneuver Control", USAGGSC.
4. FM 101-31 "Staff Officers' Field Manual: Nuclear Weapons Employment Effects Data" (FMFM 11-11), USACGSC.
5. "Tractics: Rules for Modern Warfare", Tactical Studies Rules.
6. "Addendum to Personnel Risks and Casualty Criteria" ACN 22744, March 76.
7. "Approximations for Digital Computers" Hastings C. Princeton University Press, 1955.

APPENDIX A  
LIST OF ABBREVIATIONS, ACRONYMS, AND SYMBOLS

The abbreviations, acronyms, and symbols used throughout this report are listed in this appendix. In some cases, an abbreviation used in the report is actually a combination of two other abbreviations. In these cases the combined abbreviation usually does not appear in this appendix while the individual or separate abbreviations do. For example, ARMBDE does not have an entry while ARM and BDE each do.

|                  |   |
|------------------|---|
| ACS              | Armored Cavalry Squadron                          |
| ACSCO            | Armored Support Company                           |
| ACT              | Armored Cavalry Team                              |
| ADB              | Automated Data Base                               |
| ADMIN            | Administrative                                    |
| AI               | Artificial Intelligence                           |
| AMMO             | Ammunition  |
| APC              | Armored Personnel Carrier                         |
| ARM              | Armored   |
| ARTY             | Artillery   |
| ATGM             | Anti-Tank Guided Missile                          |
| ATU              | Anti-Tank Unit                                    |
| AUTO             | Automatic Encryption                              |
| BDE              | Brigade   |
| BN               | Brigade   |
| BTY              | Battery   |
| BTY122           | 122mm Artillery Battery                           |
| BTY155           | 155mm Howitzer Battery                            |
| BTY203           | 203mm (8 inch) Artillery Batter                   |
| CAS              | Close Air Support                                 |
| CEL              | Continuous Event List                             |
| CIC              | Combat Interaction and Communication              |
| CMD              | Command   |
| CO               | Company   |
| CY               | Cycle   |
| C <sup>2</sup> I | Command, Control and Information                  |
| C <sup>3</sup> I | Command, Control, Communications and Intelligence |
| DEL              | Discrete Event List                               |
| DEP              | Deflection Error Probable                         |
| DF               | Direction Finding                                 |
| DIV              | Division  |
| DNA              | Defense Nuclear Agency                            |
| ENCPH            | Enciphered  |

|        |  |
|--------|--|
| EW     | Electronic Warfare                                       |
| FAX    | Facsimile  |
| FEBA   | Forward Edge of the Battle Area                          |
| FEL    | Furure Event List  |
| FP     | Free Play  |
| FROG   | NATO Designation of Warsaw Pact Tactical Nuclear Missile |
| HEX    | Hexagon  |
| HHB    | Headquarters and Headquarters Battalion                  |
| HHC    | Headquarters and Headquarters Company                    |
| HJBTY  | Honest John BYT  |
| HOB    | Hieght of Burst  |
| HR     | Hour   |
| IP     | Input processor  |
| INF    | Infantry   |
| INTEL  | Intelligence   |
| ITD    | Incapacitation for Demanding Tasks                       |
| KM     | Kilometers   |
| KT     | Kilotons   |
| LER    | Loss Exchange Ratio                                      |
| LOG    | Logistics  |
| MCP    | Module Control Processor                                 |
| MCSCO  | Mechanized Support Company                               |
| MECCO  | Mechanized CO  |
| MECHBN | Mechanized BN  |
| METRIC | Generic name for all models based on TCOR                |
| MHz    | Megahertz  |
| MIN    | Minutes/Minimum  |
| MISLBN | Missile BN   |
| MITL   | Man in the Loop  |
| mm     | milimeter  |
| MR     | Motorized Rifle  |
| NATO   | North Atlantic Treaty Organization                       |
| NET    | Network  |

|        |   |
|--------|---|
| NWE    | Nuclear Weapons Effects                             |
| OBE    | Overtaken by Events                                 |
| OPORD  | Operations Order                                    |
| Pk     | Probability of Kill                                 |
| REC    | Reconnaissance                                      |
| REG    | Regiment  |
| REP    | Range Error Probable                                |
| RGT    | Regiment  |
| SDS    | Simulation Data Structure                           |
| SOP    | Standard Operating Procedures                       |
| SITREP | Situation Report                                    |
| SSP    | Scenario Selection Processor                        |
| TA     | Tank Army   |
| TCOR   | Basic DNA-TCOR Tactical Combat Simulation Model     |
| TK     | Tank  |
| TLE    | Target Location Error                               |
| TRACE  | TCOR Revised to Assess Communications Effectiveness |
| TTY    | Teletypewriter                                      |
| TUBE   | Single Artillery Piece                              |
| UOIL   | User Oriented Input Language                        |
| US     | United States                                       |
| WP     | Warsaw Pact   |

---

APPENDIX B  
EXAMPLE NWE DOCUMENTATION FORMAT

Each of the seven subroutines developed for the TRACE model to account for nuclear weapons effects on the operabilities of communications equipments was thoroughly documented. An example of the documentation scheme and format is presented in this appendix along with a graph of the typical probabilistic results generated by the routine that has been used as the example.

A. PKPERS

B. Title - Programmer

Function subroutine PKPERS; programmed by R. L. Rothrock and D. L. Porter, 1978.

C. Purpose and Description

PKPERS is a part of the environmental effects portion of TCOR and is used to calculate the probability of loss of an individual due to exposure to low altitude nuclear detonations in the war game. The probability of loss of an individual can be used by higher level routines which contain information about numbers and locations of personnel to (1) compute the expected number of personnel lost and/or (2) to conduct random draws to determine the number of personnel who will be considered lost due to this war game event.

D. Assumptions

- (1) PKPERS considers loss of personnel due to exposure to nuclear detonations to be only a function of the initial radiation total dose (tissue) levels which would occur with negligible shielding against initial radiation.
- (2) Loss of personnel due to total dose is considered to be synonymous with initial transient incapacitation for demanding tasks (ITD) as defined in "Addendum to Personnel Risks and Casualty Criteria".
- (3) Height of burst (HOB) for low altitude tactical nuclear detonations is assumed to be  $60 W^{1/3}$  meters, where W is the yield of the weapon in kilotons.

E. Inputs

The inputs to PKPERS are:

- (1) YIELD - the weapon yield in kilotons
- (2) RNG - the range from the person to the ground zero point of the detonation in kilometers.

F. Output

The output is the value of PKPERS, the probability that an individual will be lost.



## G. Methodology

### 1. Introduction

The methodology underlying the PKPERS routine is a curve fitting of the probability of loss of individual personnel as a function of yield and range curves found in "Assessment and Models of Mobile Command Post Survivability in a Tactical Nuclear Environment (U)", BDM/W-78-084-TR. These curves are shown in Figure B-1. The fit to the yield parameter is continuous for yields between 1 and 100 KT and discrete for yields of 200 and 300 KT.

The curves tend to be highly linear in the parameter range and the slope of the curves with range is approximately constant for yields under 100 KT. The curves, however, are very nonlinear in the parameter yield.

### 2. Dependent on Yield Parameter for $1 \leq W \leq 100$ KT

Since the curves of probability of loss of individual personnel are linear with range for any given yield, the yield dependence can be defined if the range corresponding to a particular probability percentile can be expressed as a function of yield. The probability level used is .5, the fifty percentile level. The range R in kilometers corresponding to a given yield W in kilotons and total dose level D in rads (tissue) can be computed using the standard INCA algorithm.

$$R = 2.10 \left( \frac{D}{W} \right)^{-.135} * \exp \left[ -2.78 \times 10^{-5} \left( \frac{D}{W} \right) \right] \quad (\text{Eq. -1})$$

The 50 percentile total dose level for ITD is 2250 rads (tissue). Using this value for D in Eq. 1, the equation for  $R_{50}$  is

$$R_{50} = .741 W^{-.135} * \exp \left[ \frac{-6.26 \times 10^{-5}}{W} \right] \quad (\text{Eq. -2})$$

Computation of time consuming transcendental functions can be minimized if the logarithm of  $R_{50}$  is computed and then the inverse taken. Further efficiency can be gained by using approximation to the  $\log_{10}$  and inverse functions since very high accuracy is not called for.

The approximations used here are the Chebyshev criteria fits given by Hastings on sheets 1 and 17 of "Approximations for Digital Computers". The approximation on sheet 17 for  $10^x$  is valid for  $0 \leq x \leq 1$ . Therefore, to use this approximation we must compute the logarithm base ten of some multiple C of  $R_{50}$  which meets the criteria  $0 \leq \log_{10}(CR_{50}) \leq 1$  for all yields between one and one hundred kilotons. If we let  $C = 5.0$  these conditions will be met. Hence we compute

$$\begin{aligned} X &= \log_{10}(5.0 R_{50}) \\ &= .569 + .135 \log_{10} W - \frac{6.25 \times 10^{-2}}{W} \end{aligned} \quad (\text{Eq.-3})$$

and hence

$$R_{50} = (.20) 10^X \quad (\text{Eq.-4})$$

This procedure permits computation of  $R_{50}$  by using very fast running approximations for transcendental functions. Ranges for yields of 200 and 300 KT need not be fitted, since these are discrete yields, and thus can be taken directly from the curves.

### 3. Dependence on Range Parameter

Given the 50 percentile range  $R_{50}$  the probability of loss  $P_K$  is given by the linear fit in range RNG

$$P_K = (\text{RNG} - R_{50})m + 0.5 \quad (\text{Eq.-5})$$

where  $m$  is the slope. The obvious correction is then made to set the probability to one if  $P_K \geq 1$  and to set it to zero if  $P_K \leq 0$ .

A single slope is used for yields of 1 to 100 KT but different slopes are used for yields of 200 and 300 KT.

### 4. Other Streamlining Techniques

Since yields are limited to values between 1 and 300 KT inclusive, a range input of less than .63 kilometers will assure loss of personnel and a range greater than 1.73 kilometers will assure survival of personnel. These range tests are done first to achieve overall efficiency of the algorithm by avoiding unnecessary calculations. Testing for permissible yields is also done at the start of the routine.

H.        Limitations

The range input can be any value but the yield input must be a value between 1 and 100 or else 200 or 300. Other values of yield, such as 150, will cause the routine to default to PKPERS = 0.0 and will print an error message. This limitation of the routine should not be significant since the permissible yields cover most yields of interest.

Personnel in the open may be vulnerable to thermal radiation and blast at high yields. This routine does not model these phenomena.

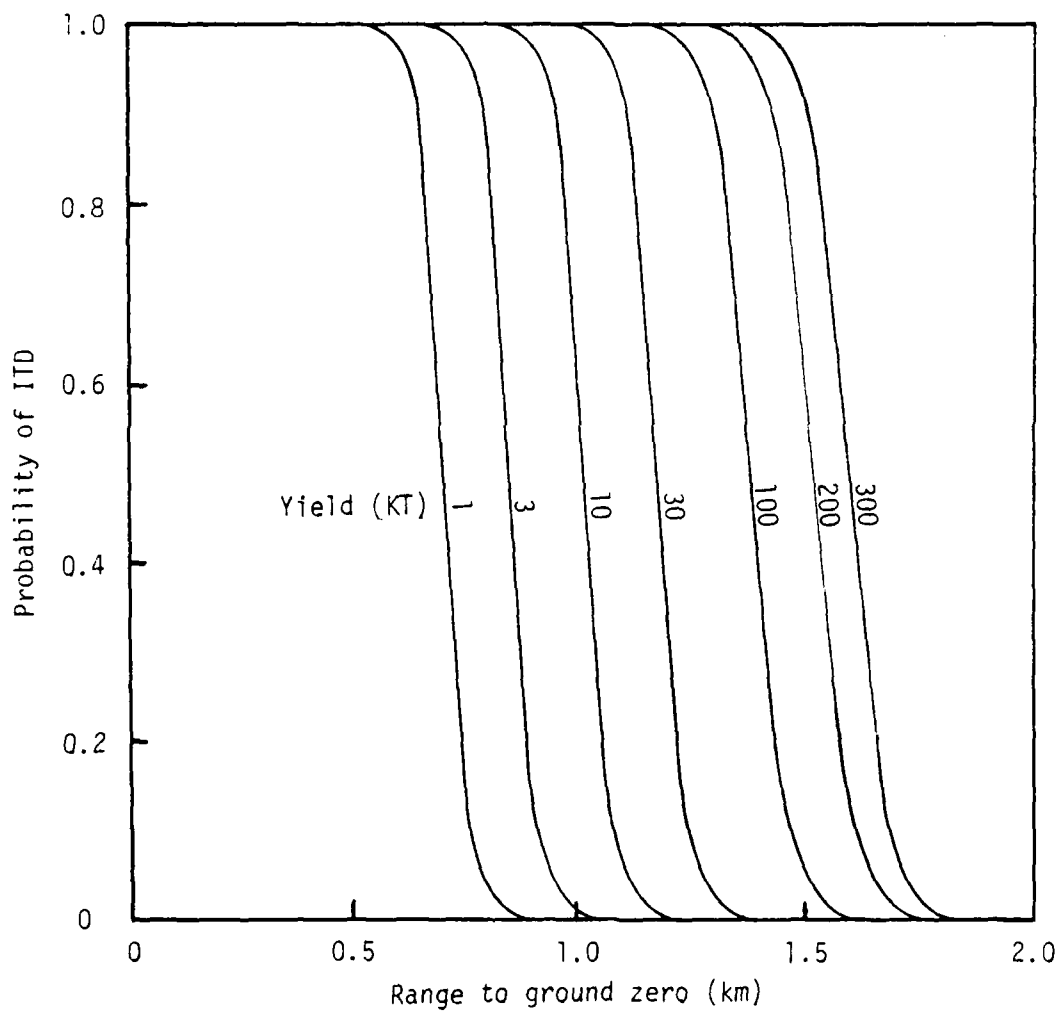


Figure B-1. Probability that an individual person experiences ITD (or worse forms of incapacitation) as a function of range and weapon yield.

APPENDIX C  
TRACE BASIC INPUT LISTING

All of the input parameters to the TRACE model are listed in card image form in this appendix. Although the combat orders specified toward the end of the listing were valid for the duration of the conflict engagement, they were overridden (changed) by the Blue Commander at approximately two-hour intervals. This basic input listing does specify, however, the starting conditions for all six TRACE cases examined. A thorough discussion of all parameters in this listing is available in reference 2.

**PART I**

**EW AND COMMUNICATIONS DATA IN CARD IMAGE FORMAT**

C\*\*\*\*\*  
 BLUE CORPS CAS NET  
 C\*\*\*\*\*

|         |          |  |
|---------|----------|--|
| 5       |          | NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS |
| 7       |          | NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN           |
| 1       |          | SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH         |
| 1       |          | TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX        |
| 28000   | CHANNELS | NUMBER OF CHANNELS                           |
| 23      | STATIONS | NUMBER OF STATIONS IN NET                    |
| 15.272  | MHZ      | NET FREQUENCY                                |
| 30.00   | MHZ      | MAX FREQUENCY                                |
| 2.00    | MHZ      | MIN FREQUENCY                                |
| 5.00    | PERCENT  | DUTY CYCLE                                   |
| 5.00    | PERCENT  | BACKGROUND TRAFFIC                           |
| 5.00    | PERCENT  | BREAK SECURITY                               |
| 2400.00 | KM       | MAX EFFECTIVE COMMUNICATION RANGE            |
| 35.00   | KM/HR    | COURIER SPEED                                |
| 2.0     | MINUTES  | AVERAGE MESSAGE LENGTH                       |
| .25     | MINUTES  | CONNECT TIME DELAY                           |
| 30.0    | MINUTES  | TIME AT WHICH TO USE COURIER                 |
| 15.0    | MINUTES  | TIME BEFORE USING ALTERNATE ROUTE            |
| 0.00    | MIN      | TIME BEFORE ALTERNATE IF JAMMED              |

|         |       |       |       |      |                      |
|---------|-------|-------|-------|------|----------------------|
| 5 CORPS | 0 DIV | 0 BDE | 0 BN  | 0 CO | 56.0 PERCENT DUTY CY |
| 5 CORPS | 3 DIV | 0 BDE | 0 BN  | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 1 BDE | 0 BN  | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 1 BDE | 11 BN | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 1 BDE | 12 BN | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 1 BDE | 13 BN | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 1 BDE | 14 BN | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 2 BDE | 0 BN  | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 2 BDE | 21 BN | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 2 BDE | 22 BN | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 2 BDE | 23 BN | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 2 BDE | 24 BN | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 3 BDE | 0 BN  | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 3 BDE | 31 BN | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 3 BDE | 32 BN | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 3 BDE | 33 BN | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 4 BDE | 0 BN  | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 4 BDE | 41 BN | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 4 BDE | 42 BN | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 4 BDE | 43 BN | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 4 BDE | 44 BN | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 4 BDE | 45 BN | 0 CO | 2.0 PERCENT DUTY CY  |
| 5 CORPS | 3 DIV | 0 BDE | 5 BN  | 0 CO | 2.0 PERCENT DUTY CY  |

C\*\*\*\*\*  
 BLUE CORPS ARTY NET

C\*\*\*\*\*

|         |          |       |       |  |
|---------|----------|-------|-------|--|
| 3       |          |       |       | NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS |
| 7       |          |       |       | NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN           |
| 1       |          |       |       | SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH         |
| 1       |          |       |       | TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX        |
| 920     | CHANNELS |       |       | NUMBER OF CHANNELS                           |
| 9       | STATIONS |       |       | NUMBER OF STATIONS IN NET                    |
| 52.37   | MHZ      |       |       | NET FREQUENCY                                |
| 75.95   | MHZ      |       |       | MAX FREQUENCY                                |
| 30.00   | MHZ      |       |       | MIN FREQUENCY                                |
| 18.00   | PERCENT  |       |       | DUTY CYCLE                                   |
| 5.00    | PERCENT  |       |       | BACKGROUND TRAFFIC                           |
| 5.00    | PERCENT  |       |       | BREAK SECURITY                               |
| 40.00   | KM       |       |       | MAX EFFECTIVE COMMUNICATION RANGE            |
| 35.00   | KM/HR    |       |       | COURIER SPEED                                |
| 1.0     | MINUTES  |       |       | AVERAGE MESSAGE LENGTH                       |
| .25     | MINUTES  |       |       | CONNECT TIME DELAY                           |
| 30.0    | MINUTES  |       |       | TIME AT WHICH TO USE COURIER                 |
| 15.0    | MINUTES  |       |       | TIME BEFORE USING ALTERNATE ROUTE            |
| 0.00    | MIN      |       |       | TIME BEFORE ALTERNATE IF JAMMED              |
| 5 CORPS | 0 DIV    | 0 BDE | 0 BN  | 0 CO 4.0 PERCENT DUTY CY                     |
| 5 CORPS | 3 DIV    | 0 BDE | 0 BN  | 0 CO 12.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 0 BDE | 5 BN  | 0 CO 12.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 4 BDE | 0 BN  | 0 CO 12.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 4 BDE | 41 BN | 0 CO 12.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 4 BDE | 42 BN | 0 CO 12.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 4 BDE | 43 BN | 0 CO 12.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 4 BDE | 44 BN | 0 CO 12.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 4 BDE | 45 BN | 0 CO 12.0 PERCENT DUTY CY                    |

C\*\*\*\*\*

BLUE 3 DIV COMMAND NET

C\*\*\*\*\*

|         |          |       |      |  |
|---------|----------|-------|------|--|
| 1       |          |       |      | NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS |
| 6       |          |       |      | NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN           |
| 1       |          |       |      | SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH         |
| 1       |          |       |      | TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX        |
| 920     | CHANNELS |       |      | NUMBER OF CHANNELS                           |
| 6       | STATIONS |       |      | NUMBER OF STATIONS IN NET                    |
| 65.05   | MHZ      |       |      | NET FREQUENCY                                |
| 75.95   | MHZ      |       |      | MAX FREQUENCY                                |
| 30.00   | MHZ      |       |      | MIN FREQUENCY                                |
| 40.00   | PERCENT  |       |      | DUTY CYCLE                                   |
| 5.00    | PERCENT  |       |      | BACKGROUND TRAFFIC                           |
| 5.00    | PERCENT  |       |      | BREAK SECURITY                               |
| 40.00   | KM       |       |      | MAX EFFECTIVE COMMUNICATION RANGE            |
| 35.00   | KM/HR    |       |      | COURIER SPEED                                |
| 2.0     | MINUTES  |       |      | AVERAGE MESSAGE LENGTH                       |
| .25     | MINUTES  |       |      | CONNECT TIME DELAY                           |
| 30.0    | MINUTES  |       |      | TIME AT WHICH TO USE COURIER                 |
| 15.0    | MINUTES  |       |      | TIME BEFORE USING ALTERNATE ROUTE            |
| 0.00    | MIN      |       |      | TIME BEFORE ALTERNATE IF JAMMED              |
| 5 CORPS | 3 DIV    | 0 BDE | 0 BN | 0 CO 50.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 1 BDE | 0 BN | 0 CO 10.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 2 BDE | 0 BN | 0 CO 10.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 3 BDE | 0 BN | 0 CO 10.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 4 BDE | 0 BN | 0 CO 10.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 0 BDE | 5 BN | 0 CO 10.0 PERCENT DUTY CY                    |



C\*\*\*\*\*  
 BLUE 3 DIV ADMIN/LOG NET  
 C\*\*\*\*\*

|         |          |  |
|---------|----------|--|
| 2       |          | NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS |
| 6       |          | NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN           |
| 1       |          | SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH         |
| 2       |          | TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX        |
| 28000   | CHANNELS | NUMBER OF CHANNELS                           |
| 6       | STATIONS | NUMBER OF STATIONS IN NET                    |
| 4.263   | MHZ      | NET FREQUENCY                                |
| 30.00   | MHZ      | MAX FREQUENCY                                |
| 2.00    | MHZ      | MIN FREQUENCY                                |
| 50.00   | PERCENT  | DUTY CYCLE                                   |
| 10.00   | PERCENT  | BACKGROUND TRAFFIC                           |
| 5.00    | PERCENT  | BREAK SECURITY                               |
| 2400.00 | KM       | MAX EFFECTIVE COMMUNICATION RANGE            |
| 25.00   | KM/HR    | COURIER SPEED                                |
| 1.5     | MINUTES  | AVERAGE MESSAGE LENGTH                       |
| .25     | MINUTES  | CONNECT TIME DELAY                           |
| 120.0   | MINUTES  | TIME AT WHICH TO USE COURIER                 |
| 45.0    | MINUTES  | TIME BEFORE USING ALTERNATE ROUTE            |
| 0.00    | MIN      | TIME BEFORE ALTERNATE IF JAMMED              |
| 5 CORPS | 3 DIV    | 0 BDE 0 BN 0 CO 50.0 PERCENT DUTY CY         |
| 5 CORPS | 3 DIV    | 1 BDE 0 BN 0 CO 10.0 PERCENT DUTY CY         |
| 5 CORPS | 3 DIV    | 2 BDE 0 BN 0 CO 10.0 PERCENT DUTY CY         |
| 5 CORPS | 3 DIV    | 3 BDE 0 BN 0 CO 10.0 PERCENT DUTY CY         |
| 5 CORPS | 3 DIV    | 4 BDE 0 BN 0 CO 10.0 PERCENT DUTY CY         |
| 5 CORPS | 3 DIV    | 0 BDE 5 BN 0 CO 10.0 PERCENT DUTY CY         |

C\*\*\*\*\*  
 BLUE 3 DIV INTEL NET  
 C\*\*\*\*\*

|         |          |  |
|---------|----------|--|
| 4       |          | NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS |
| 6       |          | NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN           |
| 1       |          | SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH         |
| 2       |          | TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX        |
| 28000   | CHANNELS | NUMBER OF CHANNELS                           |
| 6       | STATIONS | NUMBER OF STATIONS IN NET                    |
| 5.593   | MHZ      | NET FREQUENCY                                |
| 30.00   | MHZ      | MAX FREQUENCY                                |
| 2.00    | MHZ      | MIN FREQUENCY                                |
| 60.00   | PERCENT  | DUTY CYCLE                                   |
| 20.00   | PERCENT  | BACKGROUND TRAFFIC                           |
| 5.00    | PERCENT  | BREAK SECURITY                               |
| 2400.00 | KM       | MAX EFFECTIVE COMMUNICATION RANGE            |
| 35.00   | KM/HR    | COURIER SPEED                                |
| 2.5     | MINUTES  | AVERAGE MESSAGE LENGTH                       |
| .25     | MINUTES  | CONNECT TIME DELAY                           |
| 45.0    | MINUTES  | TIME AT WHICH TO USE COURIER                 |
| 20.0    | MINUTES  | TIME BEFORE USING ALTERNATE ROUTE            |
| 0.00    | MIN      | TIME BEFORE ALTERNATE IF JAMMED              |
| 5 CORPS | 3 DIV    | 0 BDE 0 BN 0 CO 50.0 PERCENT DUTY CY         |
| 5 CORPS | 3 DIV    | 1 BDE 0 BN 0 CO 10.0 PERCENT DUTY CY         |
| 5 CORPS | 3 DIV    | 2 BDE 0 BN 0 CO 10.0 PERCENT DUTY CY         |
| 5 CORPS | 3 DIV    | 3 BDE 0 BN 0 CO 10.0 PERCENT DUTY CY         |
| 5 CORPS | 3 DIV    | 4 BDE 0 BN 0 CO 10.0 PERCENT DUTY CY         |
| 5 CORPS | 3 DIV    | 0 BDE 5 BN 0 CO 10.0 PERCENT DUTY CY         |

C\*\*\*\*\*  
 BLUE 1 BDE COMMAND NET

C\*\*\*\*\*  
 1 NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS  
 5 NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN  
 1 SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH  
 1 TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX  
 920 CHANNELS NUMBER OF CHANNELS  
 5 STATIONS NUMBER OF STATIONS IN NET  
 67.71 MHZ NET FREQUENCY  
 75.95 MHZ MAX FREQUENCY  
 30.00 MHZ MIN FREQUENCY  
 50.00 PERCENT DUTY CYCLE  
 10.00 PERCENT BACKGROUND TRAFFIC  
 5.00 PERCENT BREAK SECURITY  
 40.00 KM MAX EFFECTIVE COMMUNICATION RANGE  
 35.00 KM/HR COURIER SPEED  
 2.1 MINUTES AVERAGE MESSAGE LENGTH  
 .10 MINUTES CONNECT TIME DELAY  
 15.0 MINUTES TIME AT WHICH TO USE COURIER  
 5.0 MINUTES TIME BEFORE USING ALTERNATE ROUTE  
 0.00 MIN TIME BEFORE ALTERNATE IF JAMMED  
 5 CORPS 3 DIV 1 BDE 0 BN 0 CO 52.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 1 BDE 11 BN 0 CO 12.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 1 BDE 12 BN 0 CO 12.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 1 BDE 13 BN 0 CO 12.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 1 BDE 14 BN 0 CO 12.0 PERCENT DUTY CY

C\*\*\*\*\*  
 BLUE 1 BDE ADMIN/LOG NET

C\*\*\*\*\*  
 2 NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS  
 5 NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN  
 1 SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH  
 1 TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX  
 920 CHANNELS NUMBER OF CHANNELS  
 5 STATIONS NUMBER OF STATIONS IN NET  
 35.95 MHZ NET FREQUENCY  
 75.95 MHZ MAX FREQUENCY  
 30.00 MHZ MIN FREQUENCY  
 43.00 PERCENT DUTY CYCLE  
 10.00 PERCENT BACKGROUND TRAFFIC  
 5.00 PERCENT BREAK SECURITY  
 35.00 KM MAX EFFECTIVE COMMUNICATION RANGE  
 25.00 KM/HR COURIER SPEED  
 3.0 MINUTES AVERAGE MESSAGE LENGTH  
 .25 MINUTES CONNECT TIME DELAY  
 60.0 MINUTES TIME AT WHICH TO USE COURIER  
 30.0 MINUTES TIME BEFORE USING ALTERNATE ROUTE  
 0.00 MIN TIME BEFORE ALTERNATE IF JAMMED  
 5 CORPS 3 DIV 1 BDE 0 BN 0 CO 52.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 1 BDE 11 BN 0 CO 12.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 1 BDE 12 BN 0 CO 12.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 1 BDE 13 BN 0 CO 12.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 1 BDE 14 BN 0 CO 12.0 PERCENT DUTY CY

C\*\*\*\*\*  
 BLUE 1 BDE ARTY NET

C\*\*\*\*\*  
 3 NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS  
 5 NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN  
 1 SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH  
 1 TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX  
 920 CHANNELS NUMBER OF CHANNELS  
 10 STATIONS NUMBER OF STATIONS IN NET  
 55.55 MHZ NET FREQUENCY  
 75.95 MHZ MAX FREQUENCY  
 30.00 MHZ MIN FREQUENCY  
 40.00 PERCENT DUTY CYCLE  
 5.00 PERCENT BACKGROUND TRAFFIC  
 5.00 PERCENT BREAK SECURITY  
 40.00 KM MAX EFFECTIVE COMMUNICATION RANGE  
 35.00 KM/HR COURIER SPEED  
 1.0 MINUTES AVERAGE MESSAGE LENGTH  
 .25 MINUTES CONNECT TIME DELAY  
 30.0 MINUTES TIME AT WHICH TO USE COURIER  
 15.0 MINUTES TIME BEFORE USING ALTERNATE ROUTE  
 0.00 MIN TIME BEFORE ALTERNATE IF JAMMED  
 5 CORPS 3 DIV 1 BDE 0 BN 0 CO 1.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 1 BDE 11 BN 0 CO 11.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 1 BDE 12 BN 0 CO 11.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 1 BDE 13 BN 0 CO 11.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 1 BDE 14 BN 0 CO 11.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 41 BN 0 CO 11.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 42 BN 0 CO 11.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 43 BN 0 CO 11.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 44 BN 0 CO 11.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 45 BN 0 CO 11.0 PERCENT DUTY CY

C\*\*\*\*\*  
 BLUE 1 BDE INTEL NET

C\*\*\*\*\*  
 4 NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS  
 5 NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN  
 1 SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH  
 1 TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX  
 920 CHANNELS NUMBER OF CHANNELS  
 5 STATIONS NUMBER OF STATIONS IN NET  
 37.80 MHZ NET FREQUENCY  
 75.95 MHZ MAX FREQUENCY  
 30.00 MHZ MIN FREQUENCY  
 18.00 PERCENT DUTY CYCLE  
 5.00 PERCENT BACKGROUND TRAFFIC  
 5.00 PERCENT BREAK SECURITY  
 40.00 KM MAX EFFECTIVE COMMUNICATION RANGE  
 30.00 KM/HR COURIER SPEED  
 2.3 MINUTES AVERAGE MESSAGE LENGTH  
 .10 MINUTES CONNECT TIME DELAY  
 20.0 MINUTES TIME AT WHICH TO USE COURIER  
 10.0 MINUTES TIME BEFORE USING ALTERNATE ROUTE  
 0.00 MIN TIME BEFORE ALTERNATE IF JAMMED  
 5 CORPS 3 DIV 1 BDE 0 BN 0 CO 52.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 1 BDE 11 BN 0 CO 12.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 1 BDE 12 BN 0 CO 12.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 1 BDE 13 BN 0 CO 12.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 1 BDE 14 BN 0 CO 12.0 PERCENT DUTY CY

C\*\*\*\*\*  
 BLUE 2 BDE COMMAND NET

C\*\*\*\*\*

|         |          |       |       |      |  |
|---------|----------|-------|-------|------|--|
| 1       |          |       |       |      | NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS |
| 5       |          |       |       |      | NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN           |
| 1       |          |       |       |      | SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH         |
| 1       |          |       |       |      | TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX        |
| 920     | CHANNELS |       |       |      | NUMBER OF CHANNELS                           |
| 5       | STATIONS |       |       |      | NUMBER OF STATIONS IN NET                    |
| 61.50   | MHZ      |       |       |      | NET FREQUENCY                                |
| 75.95   | MHZ      |       |       |      | MAX FREQUENCY                                |
| 30.00   | MHZ      |       |       |      | MIN FREQUENCY                                |
| 50.00   | PERCENT  |       |       |      | DUTY CYCLE                                   |
| 10.00   | PERCENT  |       |       |      | BACKGROUND TRAFFIC                           |
| 5.00    | PERCENT  |       |       |      | BREAK SECURITY                               |
| 40.00   | KM       |       |       |      | MAX EFFECTIVE COMMUNICATION RANGE            |
| 35.00   | KM/HR    |       |       |      | COURIER SPEED                                |
| 2.1     | MINUTES  |       |       |      | AVERAGE MESSAGE LENGTH                       |
| .10     | MINUTES  |       |       |      | CONNECT TIME DELAY                           |
| 15.0    | MINUTES  |       |       |      | TIME AT WHICH TO USE COURIER                 |
| 5.0     | MINUTES  |       |       |      | TIME BEFORE USING ALTERNATE ROUTE            |
| 0.00    | MIN      |       |       |      | TIME BEFORE ALTERNATE IF JAMMED              |
| 5 CORPS | 3 DIV    | 2 BDE | 0 BN  | 0 CO | 52.0 PERCENT DUTY CY                         |
| 5 CORPS | 3 DIV    | 2 BDE | 21 BN | 0 CO | 12.0 PERCENT DUTY CY                         |
| 5 CORPS | 3 DIV    | 2 BDE | 22 BN | 0 CO | 12.0 PERCENT DUTY CY                         |
| 5 CORPS | 3 DIV    | 2 BDE | 23 BN | 0 CO | 12.0 PERCENT DUTY CY                         |
| 5 CORPS | 3 DIV    | 2 BDE | 24 BN | 0 CO | 12.0 PERCENT DUTY CY                         |

C\*\*\*\*\*

BLUE 2 BDE ADMIN/LOG NET

C\*\*\*\*\*

|         |          |       |       |      |  |
|---------|----------|-------|-------|------|--|
| 2       |          |       |       |      | NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS |
| 5       |          |       |       |      | NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN           |
| 1       |          |       |       |      | SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH         |
| 1       |          |       |       |      | TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX        |
| 920     | CHANNELS |       |       |      | NUMBER OF CHANNELS                           |
| 5       | STATIONS |       |       |      | NUMBER OF STATIONS IN NET                    |
| 44.15   | MHZ      |       |       |      | NET FREQUENCY                                |
| 75.95   | MHZ      |       |       |      | MAX FREQUENCY                                |
| 30.00   | MHZ      |       |       |      | MIN FREQUENCY                                |
| 43.00   | PERCENT  |       |       |      | DUTY CYCLE                                   |
| 10.00   | PERCENT  |       |       |      | BACKGROUND TRAFFIC                           |
| 5.00    | PERCENT  |       |       |      | BREAK SECURITY                               |
| 35.00   | KM       |       |       |      | MAX EFFECTIVE COMMUNICATION RANGE            |
| 25.00   | KM/HR    |       |       |      | COURIER SPEED                                |
| 3.0     | MINUTES  |       |       |      | AVERAGE MESSAGE LENGTH                       |
| .25     | MINUTES  |       |       |      | CONNECT TIME DELAY                           |
| 60.0    | MINUTES  |       |       |      | TIME AT WHICH TO USE COURIER                 |
| 30.0    | MINUTES  |       |       |      | TIME BEFORE USING ALTERNATE ROUTE            |
| 0.00    | MIN      |       |       |      | TIME BEFORE ALTERNATE IF JAMMED              |
| 5 CORPS | 3 DIV    | 2 BDE | 0 BN  | 0 CO | 52.0 PERCENT DUTY CY                         |
| 5 CORPS | 3 DIV    | 2 BDE | 21 BN | 0 CO | 12.0 PERCENT DUTY CY                         |
| 5 CORPS | 3 DIV    | 2 BDE | 22 BN | 0 CO | 12.0 PERCENT DUTY CY                         |
| 5 CORPS | 3 DIV    | 2 BDE | 23 BN | 0 CO | 12.0 PERCENT DUTY CY                         |
| 5 CORPS | 3 DIV    | 2 BDE | 24 BN | 0 CO | 12.0 PERCENT DUTY CY                         |

C\*\*\*\*\*  
 BLUE 2 BDE ARTY NET

C\*\*\*\*\*  
 3 NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS  
 5 NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN  
 1 SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH  
 1 TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX  
 920 CHANNELS NUMBER OF CHANNELS  
 10 STATIONS NUMBER OF STATIONS IN NET  
 55.75 MHZ NET FREQUENCY  
 75.95 MHZ MAX FREQUENCY  
 30.00 MHZ MIN FREQUENCY  
 40.00 PERCENT DUTY CYCLE  
 5.00 PERCENT BACKGROUND TRAFFIC  
 5.00 PERCENT BREAK SECURITY  
 40.00 KM MAX EFFECTIVE COMMUNICATION RANGE  
 35.00 KM/HR COURIER SPEED  
 1.0 MINUTES AVERAGE MESSAGE LENGTH  
 .25 MINUTES CONNECT TIME DELAY  
 30.0 MINUTES TIME AT WHICH TO USE COURIER  
 15.0 MINUTES TIME BEFORE USING ALTERNATE ROUTE  
 0.00 MIN TIME BEFORE ALTERNATE IF JAMMED  
 5 CORPS 3 DIV 2 BDE 0 BN 0 CO 1.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 2 BDE 21 BN 0 CO 11.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 2 BDE 22 BN 0 CO 11.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 2 BDE 23 BN 0 CO 11.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 2 BDE 24 BN 0 CO 11.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 41 BN 0 CO 11.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 42 BN 0 CO 11.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 43 BN 0 CO 11.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 44 BN 0 CO 11.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 45 BN 0 CO 11.0 PERCENT DUTY CY

C\*\*\*\*\*  
 BLUE 2 BDE INTEL NET

C\*\*\*\*\*  
 4 NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS  
 5 NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN  
 1 SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH  
 1 TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX  
 920 CHANNELS NUMBER OF CHANNELS  
 5 STATIONS NUMBER OF STATIONS IN NET  
 44.05 MHZ NET FREQUENCY  
 75.95 MHZ MAX FREQUENCY  
 30.00 MHZ MIN FREQUENCY  
 18.00 PERCENT DUTY CYCLE  
 5.00 PERCENT BACKGROUND TRAFFIC  
 5.00 PERCENT BREAK SECURITY  
 40.00 KM MAX EFFECTIVE COMMUNICATION RANGE  
 30.00 KM/HR COURIER SPEED  
 2.3 MINUTES AVERAGE MESSAGE LENGTH  
 .10 MINUTES CONNECT TIME DELAY  
 20.0 MINUTES TIME AT WHICH TO USE COURIER  
 10.0 MINUTES TIME BEFORE USING ALTERNATE ROUTE  
 0.00 MIN TIME BEFORE ALTERNATE IF JAMMED  
 5 CORPS 3 DIV 2 BDE 0 BN 0 CO 52.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 2 BDE 21 BN 0 CO 12.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 2 BDE 22 BN 0 CO 12.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 2 BDE 23 BN 0 CO 12.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 2 BDE 24 BN 0 CO 12.0 PERCENT DUTY CY

C\*\*\*\*\*  
 BLUE 3 BDE COMMAND NET  
 C\*\*\*\*\*

|         |          |       |       |      |                      |  |
|---------|----------|-------|-------|------|----------------------|--|
| 1       |          |       |       |      |                      | NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS |
| 5       |          |       |       |      |                      | NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN           |
| 1       |          |       |       |      |                      | SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH         |
| 1       |          |       |       |      |                      | TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX        |
| 920     | CHANNELS |       |       |      |                      | NUMBER OF CHANNELS                           |
| 4       | STATIONS |       |       |      |                      | NUMBER OF STATIONS IN NET                    |
| 46.75   | MHZ      |       |       |      |                      | NET FREQUENCY                                |
| 75.95   | MHZ      |       |       |      |                      | MAX FREQUENCY                                |
| 30.00   | MHZ      |       |       |      |                      | MIN FREQUENCY                                |
| 50.00   | PERCENT  |       |       |      |                      | DUTY CYCLE                                   |
| 10.00   | PERCENT  |       |       |      |                      | BACKGROUND TRAFFIC                           |
| 5.00    | PERCENT  |       |       |      |                      | BREAK SECURITY                               |
| 40.00   | KM       |       |       |      |                      | MAX EFFECTIVE COMMUNICATION RANGE            |
| 35.00   | KM/HR    |       |       |      |                      | COURIER SPEED                                |
| 2.1     | MINUTES  |       |       |      |                      | AVERAGE MESSAGE LENGTH                       |
| .10     | MINUTES  |       |       |      |                      | CONNECT TIME DELAY                           |
| 15.0    | MINUTES  |       |       |      |                      | TIME AT WHICH TO USE COURIER                 |
| 5.0     | MINUTES  |       |       |      |                      | TIME BEFORE USING ALTERNATE ROUTE            |
| 0.00    | MIN      |       |       |      |                      | TIME BEFORE ALTERNATE IF JAMMED              |
| 5 CORPS | 3 DIV    | 3 BDE | 0 BN  | 0 CO | 55.0 PERCENT DUTY CY |  |
| 5 CORPS | 3 DIV    | 3 BDE | 31 BN | 0 CO | 15.0 PERCENT DUTY CY |  |
| 5 CORPS | 3 DIV    | 3 BDE | 32 BN | 0 CO | 15.0 PERCENT DUTY CY |  |
| 5 CORPS | 3 DIV    | 3 BDE | 33 BN | 0 CO | 15.0 PERCENT DUTY CY |  |

C\*\*\*\*\*  
 BLUE 3 BDE ADMIN/LOG NET  
 C\*\*\*\*\*

|         |          |       |       |      |                      |  |
|---------|----------|-------|-------|------|----------------------|--|
| 2       |          |       |       |      |                      | NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS |
| 5       |          |       |       |      |                      | NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN           |
| 1       |          |       |       |      |                      | SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH         |
| 1       |          |       |       |      |                      | TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX        |
| 920     | CHANNELS |       |       |      |                      | NUMBER OF CHANNELS                           |
| 4       | STATIONS |       |       |      |                      | NUMBER OF STATIONS IN NET                    |
| 72.50   | MHZ      |       |       |      |                      | NET FREQUENCY                                |
| 75.95   | MHZ      |       |       |      |                      | MAX FREQUENCY                                |
| 30.00   | MHZ      |       |       |      |                      | MIN FREQUENCY                                |
| 43.00   | PERCENT  |       |       |      |                      | DUTY CYCLE                                   |
| 10.00   | PERCENT  |       |       |      |                      | BACKGROUND TRAFFIC                           |
| 5.00    | PERCENT  |       |       |      |                      | BREAK SECURITY                               |
| 35.00   | KM       |       |       |      |                      | MAX EFFECTIVE COMMUNICATION RANGE            |
| 25.00   | KM/HR    |       |       |      |                      | COURIER SPEED                                |
| 3.0     | MINUTES  |       |       |      |                      | AVERAGE MESSAGE LENGTH                       |
| .25     | MINUTES  |       |       |      |                      | CONNECT TIME DELAY                           |
| 60.0    | MINUTES  |       |       |      |                      | TIME AT WHICH TO USE COURIER                 |
| 30.0    | MINUTES  |       |       |      |                      | TIME BEFORE USING ALTERNATE ROUTE            |
| 0.00    | MIN      |       |       |      |                      | TIME BEFORE ALTERNATE IF JAMMED              |
| 5 CORPS | 3 DIV    | 3 BDE | 0 BN  | 0 CO | 55.0 PERCENT DUTY CY |  |
| 5 CORPS | 3 DIV    | 3 BDE | 31 BN | 0 CO | 15.0 PERCENT DUTY CY |  |
| 5 CORPS | 3 DIV    | 3 BDE | 32 BN | 0 CO | 15.0 PERCENT DUTY CY |  |
| 5 CORPS | 3 DIV    | 3 BDE | 33 BN | 0 CO | 15.0 PERCENT DUTY CY |  |

C\*\*\*\*\*

BLUE 3 BDE ARTY NET

C\*\*\*\*\*

|         |          |       |       |  |
|---------|----------|-------|-------|--|
| 3       |          |       |       | NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS |
| 5       |          |       |       | NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN           |
| 1       |          |       |       | SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH         |
| 1       |          |       |       | TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX        |
| 920     | CHANNELS |       |       | NUMBER OF CHANNELS                           |
| 9       | STATIONS |       |       | NUMBER OF STATIONS IN NET                    |
| 58.30   | MHZ      |       |       | NET FREQUENCY                                |
| 75.95   | MHZ      |       |       | MAX FREQUENCY                                |
| 30.00   | MHZ      |       |       | MIN FREQUENCY                                |
| 40.00   | PERCENT  |       |       | DUTY CYCLE                                   |
| 5.00    | PERCENT  |       |       | BACKGROUND TRAFFIC                           |
| 5.00    | PERCENT  |       |       | BREAK SECURITY                               |
| 40.00   | KM       |       |       | MAX EFFECTIVE COMMUNICATION RANGE            |
| 35.00   | KM/HR    |       |       | COURIER SPEED                                |
| 1.0     | MINUTES  |       |       | AVERAGE MESSAGE LENGTH                       |
| .25     | MINUTES  |       |       | CONNECT TIME DELAY                           |
| 30.0    | MINUTES  |       |       | TIME AT WHICH TO USE COURIER                 |
| 15.0    | MINUTES  |       |       | TIME BEFORE USING ALTERNATE ROUTE            |
| 0.00    | MIN      |       |       | TIME BEFORE ALTERNATE IF JAMMED              |
| 5 CORPS | 3 DIV    | 3 BDE | 0 BN  | 0 CO 4.0 PERCENT DUTY CY                     |
| 5 CORPS | 3 DIV    | 3 BDE | 31 BN | 0 CO 12.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 3 BDE | 32 BN | 0 CO 12.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 3 BDE | 33 BN | 0 CO 12.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 4 BDE | 41 BN | 0 CO 12.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 4 BDE | 42 BN | 0 CO 12.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 4 BDE | 43 BN | 0 CO 12.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 4 BDE | 44 BN | 0 CO 12.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 4 BDE | 45 BN | 0 CO 12.0 PERCENT DUTY CY                    |

C\*\*\*\*\*

BLUE 3 BDE INTEL NET

C\*\*\*\*\*

|         |          |       |       |  |
|---------|----------|-------|-------|--|
| 4       |          |       |       | NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS |
| 5       |          |       |       | NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN           |
| 1       |          |       |       | SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH         |
| 1       |          |       |       | TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX        |
| 920     | CHANNELS |       |       | NUMBER OF CHANNELS                           |
| 4       | STATIONS |       |       | NUMBER OF STATIONS IN NET                    |
| 72.85   | MHZ      |       |       | NET FREQUENCY                                |
| 75.95   | MHZ      |       |       | MAX FREQUENCY                                |
| 30.00   | MHZ      |       |       | MIN FREQUENCY                                |
| 18.00   | PERCENT  |       |       | DUTY CYCLE                                   |
| 5.00    | PERCENT  |       |       | BACKGROUND TRAFFIC                           |
| 5.00    | PERCENT  |       |       | BREAK SECURITY                               |
| 40.00   | KM       |       |       | MAX EFFECTIVE COMMUNICATION RANGE            |
| 30.00   | KM/HR    |       |       | COURIER SPEED                                |
| 2.3     | MINUTES  |       |       | AVERAGE MESSAGE LENGTH                       |
| .10     | MINUTES  |       |       | CONNECT TIME DELAY                           |
| 20.0    | MINUTES  |       |       | TIME AT WHICH TO USE COURIER                 |
| 10.0    | MINUTES  |       |       | TIME BEFORE USING ALTERNATE ROUTE            |
| 0.00    | MIN      |       |       | TIME BEFORE ALTERNATE IF JAMMED              |
| 5 CORPS | 3 DIV    | 3 BDE | 0 BN  | 0 CO 55.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 3 BDE | 31 BN | 0 CO 15.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 3 BDE | 32 BN | 0 CO 15.0 PERCENT DUTY CY                    |
| 5 CORPS | 3 DIV    | 3 BDE | 33 BN | 0 CO 15.0 PERCENT DUTY CY                    |

C\*\*\*\*\*  
 BLUE 4 BDE COMMAND NET

C\*\*\*\*\*  
 1 NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS  
 5 NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN  
 1 SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH  
 1 TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX  
 920 CHANNELS NUMBER OF CHANNELS  
 6 STATIONS NUMBER OF STATIONS IN NET  
 39.10 MHZ NET FREQUENCY  
 75.95 MHZ MAX FREQUENCY  
 30.00 MHZ MIN FREQUENCY  
 50.00 PERCENT DUTY CYCLE  
 10.00 PERCENT BACKGROUND TRAFFIC  
 5.00 PERCENT BREAK SECURITY  
 40.00 KM MAX EFFECTIVE COMMUNICATION RANGE  
 30.00 KM/HR COURIER SPEED  
 2.1 MINUTES AVERAGE MESSAGE LENGTH  
 .10 MINUTES CONNECT TIME DELAY  
 15.0 MINUTES TIME AT WHICH TO USE COURIER  
 5.0 MINUTES TIME BEFORE USING ALTERNATE ROUTE  
 0.00 MIN TIME BEFORE ALTERNATE IF JAMMED  
 5 CORPS 3 DIV 4 BDE 0 BN 0 CO 50.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 41 BN 0 CO 10.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 42 BN 0 CO 10.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 43 BN 0 CO 10.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 44 BN 0 CO 10.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 45 BN 0 CO 10.0 PERCENT DUTY CY

C\*\*\*\*\*  
 BLUE 4 BDE ADMIN/LOG NET

C\*\*\*\*\*  
 2 NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS  
 5 NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN  
 1 SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH  
 1 TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX  
 920 CHANNELS NUMBER OF CHANNELS  
 6 STATIONS NUMBER OF STATIONS IN NET  
 56.95 MHZ NET FREQUENCY  
 75.95 MHZ MAX FREQUENCY  
 30.00 MHZ MIN FREQUENCY  
 43.00 PERCENT DUTY CYCLE  
 10.00 PERCENT BACKGROUND TRAFFIC  
 5.00 PERCENT BREAK SECURITY  
 35.00 KM MAX EFFECTIVE COMMUNICATION RANGE  
 25.00 KM/HR COURIER SPEED  
 3.0 MINUTES AVERAGE MESSAGE LENGTH  
 .25 MINUTES CONNECT TIME DELAY  
 60.0 MINUTES TIME AT WHICH TO USE COURIER  
 30.0 MINUTES TIME BEFORE USING ALTERNATE ROUTE  
 0.00 MIN TIME BEFORE ALTERNATE IF JAMMED  
 5 CORPS 3 DIV 4 BDE 0 BN 0 CO 50.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 41 BN 0 CO 10.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 42 BN 0 CO 10.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 43 BN 0 CO 10.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 44 BN 0 CO 10.0 PERCENT DUTY CY  
 5 CORPS 3 DIV 4 BDE 45 BN 0 CO 10.0 PERCENT DUTY CY



C\*\*\*\*\*  
 BLUE 4 BDE ARTY NET  
 C\*\*\*\*\*

|         |          |  |
|---------|----------|--|
| 3       |          | NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS |
| 5       |          | NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN           |
| 1       |          | SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH         |
| 1       |          | TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX        |
| 920     | CHANNELS | NUMBER OF CHANNELS                           |
| 6       | STATIONS | NUMBER OF STATIONS IN NET                    |
| 56.25   | MHZ      | NET FREQUENCY                                |
| 75.95   | MHZ      | MAX FREQUENCY                                |
| 30.00   | MHZ      | MIN FREQUENCY                                |
| 40.00   | PERCENT  | DUTY CYCLE                                   |
| 5.00    | PERCENT  | BACKGROUND TRAFFIC                           |
| 5.00    | PERCENT  | BREAK SECURITY                               |
| 40.00   | KM       | MAX EFFECTIVE COMMUNICATION RANGE            |
| 35.00   | KM/HR    | COURIER SPEED                                |
| 1.0     | MINUTES  | AVERAGE MESSAGE LENGTH                       |
| .25     | MINUTES  | CONNECT TIME DELAY                           |
| 30.0    | MINUTES  | TIME AT WHICH TO USE COURIER                 |
| 15.0    | MINUTES  | TIME BEFORE USING ALTERNATE ROUTE            |
| 0.00    | MIN      | TIME BEFORE ALTERNATE IF JAMMED              |
| 5 CORPS | 3 DIV    | 4 BDE 0 BN 0 CO 5.0 PERCENT DUTY CY          |
| 5 CORPS | 3 DIV    | 4 BDE 41 BN 0 CO 19.0 PERCENT DUTY CY        |
| 5 CORPS | 3 DIV    | 4 BDE 42 BN 0 CO 19.0 PERCENT DUTY CY        |
| 5 CORPS | 3 DIV    | 4 BDE 43 BN 0 CO 19.0 PERCENT DUTY CY        |
| 5 CORPS | 3 DIV    | 4 BDE 44 BN 0 CO 19.0 PERCENT DUTY CY        |
| 5 CORPS | 3 DIV    | 4 BDE 45 BN 0 CO 19.0 PERCENT DUTY CY        |

C\*\*\*\*\*  
 BLUE 4 BDE INTEL NET  
 C\*\*\*\*\*

|         |          |  |
|---------|----------|--|
| 4       |          | NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS |
| 5       |          | NET LEVEL 7-CORPS/6-DIV/5-BDE/4-BN           |
| 1       |          | SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH         |
| 1       |          | TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX        |
| 920     | CHANNELS | NUMBER OF CHANNELS                           |
| 6       | STATIONS | NUMBER OF STATIONS IN NET                    |
| 57.15   | MHZ      | NET FREQUENCY                                |
| 75.95   | MHZ      | MAX FREQUENCY                                |
| 30.00   | MHZ      | MIN FREQUENCY                                |
| 18.00   | PERCENT  | DUTY CYCLE                                   |
| 5.00    | PERCENT  | BACKGROUND TRAFFIC                           |
| 5.00    | PERCENT  | BREAK SECURITY                               |
| 40.00   | KM       | MAX EFFECTIVE COMMUNICATION RANGE            |
| 30.00   | KM/HR    | COURIER SPEED                                |
| 2.3     | MINUTES  | AVERAGE MESSAGE LENGTH                       |
| .10     | MINUTES  | CONNECT TIME DELAY                           |
| 20.0    | MINUTES  | TIME AT WHICH TO USE COURIER                 |
| 10.0    | MINUTES  | TIME BEFORE USING ALTERNATE ROUTE            |
| 0.00    | MIN      | TIME BEFORE ALTERNATE IF JAMMED              |
| 5 CORPS | 3 DIV    | 4 BDE 0 BN 0 CO 50.0 PERCENT DUTY CY         |
| 5 CORPS | 3 DIV    | 4 BDE 41 BN 0 CO 10.0 PERCENT DUTY CY        |
| 5 CORPS | 3 DIV    | 4 BDE 42 BN 0 CO 10.0 PERCENT DUTY CY        |
| 5 CORPS | 3 DIV    | 4 BDE 43 BN 0 CO 10.0 PERCENT DUTY CY        |
| 5 CORPS | 3 DIV    | 4 BDE 44 BN 0 CO 10.0 PERCENT DUTY CY        |
| 5 CORPS | 3 DIV    | 4 BDE 45 BN 0 CO 10.0 PERCENT DUTY CY        |

C\*\*\*\*\*

RED VHF JAMMER

C\*\*\*\*\*

|       |          |  |       |        |
|-------|----------|--|-------|--------|
| 1     | TYPE     | TYPE EQUIPMENT 1-JAM,2-LISTEN,3-DF       |       |        |
| 0     | SCANNERS | NUMBER OF SCANNERS                       |       |        |
| 0     | NETS     | NUMBER OF PRIMARY NETS TARGETED AGAINST  |       |        |
| 0     | POLICY   | EW POLICY FOR THIS EQUIPMENT             |       |        |
| 2     | UNITS    | NUMBER OF UNITS WITH THIS TYPE EQUIPMENT |       |        |
| 25.   | KM       | MAXIMUM EFFECTIVE DISTANCE               |       |        |
| 75.95 | MHZ      | MAXIMUM FREQUENCY                        |       |        |
| 30.05 | MHZ      | MINIMUM FREQUENCY                        |       |        |
| 5.00  | MHZ      | BANDWIDTH                                |       |        |
| 0.0   | SECONDS  | MINIMUM TIME TO SCAN/DF A SIGNAL         |       |        |
| 0.0   | SECONDS  | SCAN TIME PER CHANNEL                    |       |        |
| 1 TA  | 9 DIV    | 8 REG                                    | 81 BN | 814 CO |
| 1 TA  | 9 DIV    | 8 REG                                    | 81 BN | 815 CO |

C\*\*\*\*\*

RED HF JAMMER

C\*\*\*\*\*

|      |          |  |       |        |
|------|----------|--|-------|--------|
| 1    | TYPE     | TYPE EQUIPMENT 1-JAM,2-LISTEN,3-DF       |       |        |
| 0    | SCANNERS | NUMBER OF SCANNERS                       |       |        |
| 0    | NETS     | NUMBER OF PRIMARY NETS TARGETED AGAINST  |       |        |
| 0    | POLICY   | EW POLICY FOR THIS EQUIPMENT             |       |        |
| 2    | UNITS    | NUMBER OF UNITS WITH THIS TYPE EQUIPMENT |       |        |
| 500. | KM       | MAXIMUM EFFECTIVE DISTANCE               |       |        |
| 30.0 | MHZ      | MAXIMUM FREQUENCY                        |       |        |
| 2.0  | MHZ      | MINIMUM FREQUENCY                        |       |        |
| 5.00 | MHZ      | BANDWIDTH                                |       |        |
| 0.0  | SECONDS  | MINIMUM TIME TO SCAN/DF A SIGNAL         |       |        |
| 0.0  | SECONDS  | SCAN TIME PER CHANNEL                    |       |        |
| 1 TA | 9 DIV    | 8 REG                                    | 82 BN | 824 CO |
| 1 TA | 9 DIV    | 8 REG                                    | 82 BN | 825 CO |

C\*\*\*\*\*

RED VHF LISTENER

C\*\*\*\*\*

|       |          |  |       |        |
|-------|----------|--|-------|--------|
| 2     | TYPE     | TYPE EQUIPMENT 1-JAM,2-LISTEN,3-DF       |       |        |
| 5     | SCANNERS | NUMBER OF SCANNERS                       |       |        |
| 0     | NETS     | NUMBER OF PRIMARY NETS TARGETED AGAINST  |       |        |
| 0     | POLICY   | EW POLICY FOR THIS EQUIPMENT             |       |        |
| 1     | UNITS    | NUMBER OF UNITS WITH THIS TYPE EQUIPMENT |       |        |
| 30.0  | KM       | MAXIMUM EFFECTIVE DISTANCE               |       |        |
| 75.95 | MHZ      | MAXIMUM FREQUENCY                        |       |        |
| 30.05 | MHZ      | MINIMUM FREQUENCY                        |       |        |
| 00.00 | MHZ      | BANDWIDTH                                |       |        |
| 30.0  | SECONDS  | MINIMUM TIME TO SCAN/DF A SIGNAL         |       |        |
| .5    | SECONDS  | SCAN TIME PER CHANNEL                    |       |        |
| 1 TA  | 9 DIV    | 8 REG                                    | 81 BN | 810 CO |

```

C*****
RED HF LISTENER
C*****
      2   TYPE           TYPE EQUIPMENT 1-JAM,2-LISTEN,3-DF
     10   SCANNERS      NUMBER OF SCANNERS
      0   NETS          NUMBER OF PRIMARY NETS TARGETED AGAINST
      0   POLICY         EW POLICY FOR THIS EQUIPMENT
      1   UNITS          NUMBER OF UNITS WITH THIS TYPE EQUIPMENT
    700.0  KM            MAXIMUM EFFECTIVE DISTANCE
     30.0  MHZ           MAXIMUM FREQUENCY
      2.0  MHZ           MINIMUM FREQUENCY
     00.00  MHZ          BANDWIDTH
     45.0  SECONDS       MINIMUM TIME TO SCAN/DF A SIGNAL
      .5   SECONDS       SCAN TIME PER CHANNEL
    1 TA      9 DIV      8 REG      82 BN      820 CO
C*****
RED VHF DF
C*****
      3   TYPE           TYPE EQUIPMENT 1-JAM,2-LISTEN,3-DF
      0   SCANNERS      NUMBER OF SCANNERS
      0   NETS          NUMBER OF PRIMARY NETS TARGETED AGAINST
      0   POLICY         EW POLICY FOR THIS EQUIPMENT
      3   UNITS          NUMBER OF UNITS WITH THIS TYPE EQUIPMENT
     25.0  KM            MAXIMUM EFFECTIVE DISTANCE
     75.95  MHZ           MAXIMUM FREQUENCY
     30.05  MHZ           MINIMUM FREQUENCY
     00.00  MHZ          BANDWIDTH
     30.0  SECONDS       MINIMUM TIME TO SCAN/DF A SIGNAL
      0.0  SECONDS       SCAN TIME PER CHANNEL
    1 TA      9 DIV      8 REG      81 BN      811 CO
    1 TA      9 DIV      8 REG      81 BN      812 CO
    1 TA      9 DIV      8 REG      81 BN      813 CO
C*****
RED HF DF
C*****
      3   TYPE           TYPE EQUIPMENT 1-JAM,2-LISTEN,3-DF
      0   SCANNERS      NUMBER OF SCANNERS
      0   NETS          NUMBER OF PRIMARY NETS TARGETED AGAINST
      0   POLICY         EW POLICY FOR THIS EQUIPMENT
      3   UNITS          NUMBER OF UNITS WITH THIS TYPE EQUIPMENT
     700.0  KM            MAXIMUM EFFECTIVE DISTANCE
     30.0  MHZ           MAXIMUM FREQUENCY
      2.0  MHZ           MINIMUM FREQUENCY
     00.00  MHZ          BANDWIDTH
     45.0  SECONDS       MINIMUM TIME TO SCAN/DF A SIGNAL
      0.0  SECONDS       SCAN TIME PER CHANNEL
    1 TA      9 DIV      8 REG      82 BN      821 CO
    1 TA      9 DIV      8 REG      82 BN      822 CO
    1 TA      9 DIV      8 REG      82 BN      823 CO

```

## PART II

### UNIT KILL, MOVEMENT, AND AQUISITION CAPABILITIES

Because the input is just a string of numbers on cards, the model's echo check of the data is presented.

# WEAPON SYSTEM CHARACTERISTICS:

## BLUE SYSTEMS:

### - ATTRITION FACTORS (PROBABILITIES OF KILL PER UNIT TIME)

| BLUE | INFANTRY AGAINST | INFANTRY | CONVENTIONAL WEAPONS | ROCKET  |
|------|------------------|----------|----------------------|---------|
| BLUE | ARMOR AGAINST    | .00300   | ARMOR                | TUBE    |
| BLUE | TUBES AGAINST    | .00470   | .00260               | .00010  |
| BLUE | ROCKETS AGAINST  | .00300   | .10165               | .00010  |
|      |                  | .00000   | .00900               | .00010  |
|      |                  |          | 0.00000              | 0.00000 |

| BLUE | TUBES AGAINST   | INFANTRY | NUCLEAR WEAPONS | ROCKET |
|------|-----------------|----------|-----------------|--------|
| BLUE | ROCKETS AGAINST | .44000   | ARMOR           | TUBE   |
|      |                 | .75000   | .35000          | .90000 |
|      |                 |          | .45000          | .61000 |

### - MAXIMUM FIRING RANGE (IN METERS)

| INFANTRY | ROCKET |
|----------|--------|
| 3000     | 95000  |

### - MAXIMUM RATE OF FIRE (IN ROUNDS/MIN/WEAPON)

| INFANTRY | ROCKET  |
|----------|---------|
| .22700   | 1.00000 |

### - MAXIMUM RATE OF MOVEMENT (IN CM/SEC)

| INFANTRY | ROCKET |
|----------|--------|
| 666      | 666    |

### - MAXIMUM ACQUISITION RANGE (IN METERS)

| INFANTRY | ROCKET |
|----------|--------|
| 3000     | 3000   |

HMC  
666

HMC  
18000

# RED SYSTEMS:

## - ATTRITION FACTORS (PROBABILITIES OF KILL PER UNIT TIME)

| RED | INFANTRY AGAINST | CONVENTIONAL WEAPONS |         |         | ROCKET  |
|-----|------------------|----------------------|---------|---------|---------|
|     |                  | INFANTRY             | ARMOR   | TUBE    |         |
| RED | ARMOR AGAINST    | .00580               | .00580  | .00010  | .00010  |
| RED | TUBES AGAINST    | .00580               | .00700  | .00010  | .00010  |
| RED | ROCKETS AGAINST  | .00300               | .00400  | .00110  | .00010  |
| RED |                  | 0.00000              | 0.00000 | 0.00000 | 0.00000 |

| RED | TUBES AGAINST   | NUCLEAR WEAPONS |        |        | ROCKET |
|-----|-----------------|-----------------|--------|--------|--------|
|     |                 | INFANTRY        | ARMOR  | TUBE   |        |
| RED | ROCKETS AGAINST | .42000          | .32000 | .90000 | .70000 |
| RED |                 | .50000          | .48000 | .75000 | .32000 |

## - MAXIMUM FIRE RANGE (IN METERS)

|          |      |       |      |      |       |        |       |
|----------|------|-------|------|------|-------|--------|-------|
| INFANTRY | 3000 | ARMOR | 2000 | TUBE | 18000 | ROCKET | 75000 |
|----------|------|-------|------|------|-------|--------|-------|

## - MAXIMUM RATE OF FIRE (IN ROUNDS/MIN/WEAPON)

|          |        |       |        |      |         |        |         |
|----------|--------|-------|--------|------|---------|--------|---------|
| INFANTRY | .21400 | ARMOR | .56800 | TUBE | 2.64000 | ROCKET | 1.00000 |
|----------|--------|-------|--------|------|---------|--------|---------|

## - MAXIMUM RATE OF MOVEMENT (IN CM/SEC)

|          |     |       |     |      |     |        |         |
|----------|-----|-------|-----|------|-----|--------|---------|
| INFANTRY | 666 | ARMOR | 666 | TUBE | 666 | ROCKET | 666     |
|          |     |       |     |      |     |        | HHC 666 |

## - MAXIMUM ACQUISITION RANGE (IN METERS)

|          |      |       |      |      |      |        |           |
|----------|------|-------|------|------|------|--------|-----------|
| INFANTRY | 3000 | ARMOR | 3000 | TUBE | 3000 | ROCKET | 3000      |
|          |      |       |      |      |      |        | HHC 18000 |

**PART III**

**BLUE AND RED FORCE DESCRIPTIONS, RESOURCES,  
AND LOCATIONS IN CARD IMAGE FORMAT.**

NATO.  
US.

- 5 CORPS COMMANDS 5 HHC.
  - 5 HHC IS AT HEX 777773277 .
  - 5 HHC HAS 1 APC, 40 ROUNDS, 100 RADIOS.
- 5 CORPS COMMANDS 3 ARMDIV.
  - 3 ARMDIV COMMANDS 3 HHC.
    - 3 HHC IS AT HEX 777773663 .
    - 3 HHC HAS 1 APC, 40 ROUNDS, 14 RADIOS.
  - 3 ARMDIV COMMANDS 1 ARMBDE.
    - 1 ARMBDE COMMANDS 10 HHC.
      - 10 HHC IS AT HEX 777772777 .
      - 10 HHC HAS 1 APC, 40 ROUNDS, 20 RADIOS.
    - 1 ARMBDE COMMANDS 11 MECHBN.
      - 11 MECHBN COMMANDS 110 HHC.
        - 110 HHC IS AT HEX 777772762 .
        - 110 HHC HAS 1 APC, 40 ROUNDS, 25 RADIOS.
      - 11 MECHBN COMMANDS 111 MECCO.
        - 111 MECCO IS AT HEX 777772677 .
        - 111 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
      - 11 MECHBN COMMANDS 112 MECCO.
        - 112 MECCO IS AT HEX 777772673 .
        - 112 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
      - 11 MECHBN COMMANDS 113 MECCO.
        - 113 MECCO IS AT HEX 777772634 .
        - 113 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
      - 11 MECHBN COMMANDS 114 MCSCO.
        - 114 MCSCO IS AT HEX 777772671 .
        - 114 MCSCO HAS 10 TANKS, 1 TUBE, 556 ROUNDS.
    - 1 ARMBDE COMMANDS 12 MECHBN.
      - 12 MECHBN COMMANDS 120 HHC.
        - 120 HHC IS AT HEX 777772721 .
        - 120 HHC HAS 1 APC, 40 ROUNDS, 25 RADIOS.
      - 12 MECHBN COMMANDS 121 MECCO.
        - 121 MECCO IS AT HEX 777772631 .
        - 121 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
      - 12 MECHBN COMMANDS 122 MECCO.
        - 122 MECCO IS AT HEX 777772264 .
        - 122 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
      - 12 MECHBN COMMANDS 123 MECCO.
        - 123 MECCO IS AT HEX 777772265 .
        - 123 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
      - 12 MECHBN COMMANDS 124 MCSCO.
        - 124 MCSCO IS AT HEX 777772242 .
        - 124 MCSCO HAS 10 TANKS, 1 TUBE, 556 ROUNDS.
    - 1 ARMBDE COMMANDS 13 ARMBN.
      - 13 ARMBN COMMANDS 130 HHC.
        - 130 HHC IS AT HEX 777772724 .
        - 130 HHC HAS 3 TANKS, 189 ROUNDS, 30 RADIOS.
      - 13 ARMBN COMMANDS 131 ARMCO.
        - 131 ARMCO IS AT HEX 777772612 .
        - 131 ARMCO HAS 17 TANKS, 1055 ROUNDS.
      - 13 ARMBN COMMANDS 132 ARMCO.
        - 132 ARMCO IS AT HEX 777772635 .
        - 132 ARMCO HAS 17 TANKS, 1055 ROUNDS.
      - 13 ARMBN COMMANDS 133 ARMCO.
        - 133 ARMCO IS AT HEX 777772246 .
        - 133 ARMCO HAS 17 TANKS, 1055 ROUNDS.
      - 13 ARMBN COMMANDS 134 ACSCO.
        - 134 ACSCO IS AT HEX 777772613 .
        - 134 ACSCO HAS 10 TANKS, 1 TUBE, 888 ROUNDS.



1 ARMBDE COMMANDS 14 ARMBN.  
 14 ARMBN COMMANDS 140 HHC.  
 140 HHC IS AT HEX 777772772 .  
 140 HHC HAS 3 TANKS, 189 ROUNDS, 30 RADIOS.  
 14 ARMBN COMMANDS 141 ARMCO.  
 141 ARMCO IS AT HEX 777772727 .  
 141 ARMCO HAS 17 TANKS, 1055 ROUNDS.  
 14 ARMBN COMMANDS 142 ARMCO.  
 142 ARMCO IS AT HEX 777772726 .  
 142 ARMCO HAS 17 TANKS, 1055 ROUNDS.  
 14 ARMBN COMMANDS 143 ARMCO.  
 143 ARMCO IS AT HEX 777772763 .  
 143 ARMCO HAS 17 TANKS, 1055 ROUNDS.  
 14 ARMBN COMMANDS 144 ACSCO.  
 144 ACSCO IS AT HEX 777772724 .  
 144 ACSCO HAS 10 TANKS, 1 TUBE, 888 ROUNDS.  
 3 ARMOIV COMMANDS 2 ARMBDE.  
 2 ARMBDE COMMANDS 20 HHC.  
 20 HHC IS AT HEX 777772542 .  
 20 HHC HAS 1 APC, 40 ROUNDS, 20 RADIOS.  
 2 ARMBDE COMMANDS 21 MECHBN.  
 21 MECHBN COMMANDS 210 HHC.  
 210 HHC IS AT HEX 777772442 .  
 210 HHC HAS 1 APC, 40 ROUNDS, 25 RADIOS.  
 21 MECHBN COMMANDS 211 MECCO.  
 211 MECCO IS AT HEX 777776375 .  
 211 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.  
 21 MECHBN COMMANDS 212 MECCO.  
 212 MECCO IS AT HEX 777776371 .  
 212 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.  
 21 MECHBN COMMANDS 213 MECCO.  
 213 MECCO IS AT HEX 777776312 .  
 213 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.  
 21 MECHBN COMMANDS 214 MCSCO.  
 214 MCSCO IS AT HEX 777776316 .  
 214 MCSCO HAS 10 TANKS, 1 TUBE, 556 ROUNDS.  
 2 ARMBDE COMMANDS 22 MECHBN.  
 22 MECHBN COMMANDS 220 HHC.  
 220 HHC IS AT HEX 777772435 .  
 220 HHC HAS 1 APC, 40 ROUNDS, 25 RADIOS.  
 22 MECHBN COMMANDS 221 MECCO.  
 221 MECCO IS AT HEX 777772646 .  
 221 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.  
 22 MECHBN COMMANDS 222 MECCO.  
 222 MECCO IS AT HEX 777772642 .  
 222 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.  
 22 MECHBN COMMANDS 223 MECCO.  
 223 MECCO IS AT HEX 777772643 .  
 223 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.  
 22 MECHBN COMMANDS 224 MCSCO.  
 224 MCSCO IS AT HEX 777772647 .  
 224 MCSCO HAS 10 TANKS, 1 TUBE, 556 ROUNDS.

2 ARMBDE COMMANDS 23 ARMBN.  
 23 ARMBN COMMANDS 230 HHC.  
 230 HHC IS AT HEX 77772443 .  
 230 HHC HAS 3 TANKS, 189 ROUNDS, 30 RADIOS.  
 23 ARMBN COMMANDS 231 ARMCO.  
 231 ARMCO IS AT HEX 77776351 .  
 231 ARMCO HAS 17 TANKS, 1055 ROUNDS.  
 23 ARMBN COMMANDS 232 ARMCO.  
 232 ARMCO IS AT HEX 77776314 .  
 232 ARMCO HAS 17 TANKS, 1055 ROUNDS.  
 23 ARMBN COMMANDS 233 ARMCO.  
 233 ARMCO IS AT HEX 77776315 .  
 233 ARMCO HAS 17 TANKS, 1055 ROUNDS.  
 23 ARMBN COMMANDS 234 ACSCO.  
 234 ACSCO IS AT HEX 77776315 .  
 234 ACSCO HAS 10 TANKS, 1 TUBE, 888 ROUNDS.  
 2 ARMBDE COMMANDS 24 ARMBN.  
 24 ARMBN COMMANDS 240 HHC.  
 240 HHC IS AT HEX 77772435 .  
 240 HHC HAS 3 TANKS, 189 ROUNDS, 30 RADIOS.  
 24 ARMBN COMMANDS 241 ARMCO.  
 241 ARMCO IS AT HEX 77772422 .  
 241 ARMCO HAS 17 TANKS, 1055 ROUNDS.  
 24 ARMBN COMMANDS 242 ARMCO.  
 242 ARMCO IS AT HEX 77772645 .  
 242 ARMCO HAS 17 TANKS, 1055 ROUNDS.  
 24 ARMBN COMMANDS 243 ARMCO.  
 243 ARMCO IS AT HEX 77772656 .  
 243 ARMCO HAS 17 TANKS, 1055 ROUNDS.  
 24 ARMBN COMMANDS 244 ACSCO.  
 244 ACSCO IS AT HEX 77772422 .  
 244 ACSCO HAS 10 TANKS, 1 TUBE, 888 ROUNDS.  
 3 ARMDIV COMMANDS 3 ARMBDE.  
 3 ARMBDE COMMANDS 30 HHC.  
 30 HHC IS AT HEX 77772571 .  
 30 HHC HAS 1 APC, 40 ROUNDS, 20 RADIOS.  
 3 ARMBDE COMMANDS 31 MECHBN.  
 31 MECHBN COMMANDS 310 HHC.  
 310 HHC IS AT HEX 777727573 .  
 310 HHC HAS 1 APC, 40 ROUNDS, 25 RADIOS.  
 31 MECHBN COMMANDS 311 MECCO.  
 311 MECCO IS AT HEX 777727413 .  
 311 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.  
 31 MECHBN COMMANDS 312 MECCO.  
 312 MECCO IS AT HEX 77772744 .  
 312 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.  
 31 MECHBN COMMANDS 313 MECCO.  
 313 MECCO IS AT HEX 77772747 .  
 313 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.  
 31 MECHBN COMMANDS 314 MCSCO.  
 314 MCSCO IS AT HEX 77772744 .  
 314 MCSCO HAS 10 TANKS, 1 TUBE, 556 ROUNDS.

3 ARMBDE COMMANDS 32 ARMBN.  
 32 ARMBN COMMANDS 320 HHC.  
 320 HHC IS AT HEX 77772534 .  
 320 HHC HAS 3 TANKS, 189 ROUNDS, 30 RADIOS.  
 32 ARMBN COMMANDS 321 ARMCO.  
 321 ARMCO IS AT HEX 77772775 .  
 321 ARMCO HAS 17 TANKS, 1048 ROUNDS.  
 32 ARMBN COMMANDS 322 ARMCO.  
 322 ARMCO IS AT HEX 77772771 .  
 322 ARMCO HAS 17 TANKS, 1055 ROUNDS.  
 32 ARMBN COMMANDS 323 ARMCO.  
 323 ARMCO IS AT HEX 77772734 .  
 323 ARMCO HAS 17 TANKS, 1055 ROUNDS.  
 32 ARMBN COMMANDS 324 ACSCO.  
 324 ACSCO IS AT HEX 77772734 .  
 324 ACSCO HAS 10 TANKS, 1 TUBE, 888 ROUNDS.  
 3 ARMBDE COMMANDS 33 ARMBN.  
 33 ARMBN COMMANDS 330 HHC.  
 330 HHC IS AT HEX 77772544 .  
 330 HHC HAS 3 TANKS, 189 ROUNDS, 30 RADIOS.  
 33 ARMBN COMMANDS 331 ARMCO.  
 331 ARMCO IS AT HEX 77772451 .  
 331 ARMCO HAS 17 TANKS, 1055 ROUNDS.  
 33 ARMBN COMMANDS 332 ARMCO.  
 332 ARMCO IS AT HEX 77772457 .  
 332 ARMCO HAS 17 TANKS, 1055 ROUNDS.  
 33 ARMBN COMMANDS 333 ARMCO.  
 333 ARMCO IS AT HEX 77772456 .  
 333 ARMCO HAS 17 TANKS, 1055 ROUNDS.  
 33 ARMBN COMMANDS 334 ACSCO.  
 334 ACSCO IS AT HEX 77772456 .  
 334 ACSCO HAS 10 TANKS, 1 TUBE, 888 ROUNDS.  
 3 ARMDIV COMMANDS 4 DIVARTY.  
 4 DIVARTY COMMANDS 40 HHC.  
 40 HHC IS AT HEX 77772571 .  
 40 HHC HAS 1 APC, 40 ROUNDS, 43 RADIOS.  
 4 DIVARTY COMMANDS 41 ARTYBN.  
 41 ARTYBN COMMANDS 410 HMB.  
 410 HMB IS AT HEX 77772777 .  
 410 HMB HAS 1 APC, 40 ROUNDS, 31 RADIOS.  
 41 ARTYBN COMMANDS 411 BTY155.  
 411 BTY155 IS AT HEX 77772243 .  
 411 BTY155 HAS 6 TUBES, 1404 ROUNDS.  
 41 ARTYBN COMMANDS 412 BTY155.  
 412 BTY155 IS AT HEX 77772635 .  
 412 BTY155 HAS 6 TUBES, 1404 ROUNDS.  
 41 ARTYBN COMMANDS 413 BTY155.  
 413 BTY155 IS AT HEX 77772675 .  
 413 BTY155 HAS 6 TUBES, 1404 ROUNDS.  
 4 DIVARTY COMMANDS 42 ARTYBN.  
 42 ARTYBN COMMANDS 420 HMB.  
 420 HMB IS AT HEX 77772477 .  
 420 HMB HAS 1 APC, 40 ROUNDS, 31 RADIOS.  
 42 ARTYBN COMMANDS 421 BTY155.  
 421 BTY155 IS AT HEX 77772645 .  
 421 BTY155 HAS 6 TUBES, 1404 ROUNDS.  
 42 ARTYBN COMMANDS 422 BTY155.  
 422 BTY155 IS AT HEX 77772426 .  
 422 BTY155 HAS 6 TUBES, 1404 ROUNDS.  
 42 ARTYBN COMMANDS 423 BTY155.  
 423 BTY155 IS AT HEX 77776314 .  
 423 BTY155 HAS 6 TUBES, 1404 ROUNDS.

- 4 DIVARTY COMMANDS 43 ARTYBN.
  - 43 ARTYBN COMMANDS 430 HMB.
    - 430 HMB IS AT HEX 777773662 .
    - 430 HMB HAS 1 APC, 40 ROUNDS, 31 RADIOS.
  - 43 ARTYBN COMMANDS 431 BTY155.
    - 431 BTY155 IS AT HEX 777772725 .
    - 431 BTY155 HAS 6 TUBES, 1404 ROUNDS.
  - 43 ARTYBN COMMANDS 432 BTY155.
    - 432 BTY155 IS AT HEX 777772764 .
    - 432 BTY155 HAS 6 TUBES, 1404 ROUNDS.
  - 43 ARTYBN COMMANDS 433 BTY155.
    - 433 BTY155 IS AT HEX 777772477 .
    - 433 BTY155 HAS 6 TUBES, 1404 ROUNDS.
- 4 DIVARTY COMMANDS 44 ARTYBN.
  - 44 ARTYBN COMMANDS 440 HMB.
    - 440 HMB IS AT HEX 777772512 .
    - 440 HMB HAS 1 APC, 40 ROUNDS, 16 RADIOS.
  - 44 ARTYBN COMMANDS 441 BTY203.
    - 441 BTY203 IS AT HEX 777772761 .
    - 441 BTY203 HAS 4 TUBES, 560 ROUNDS.
  - 44 ARTYBN COMMANDS 442 BTY203.
    - 442 BTY203 IS AT HEX 777772434 .
    - 442 BTY203 HAS 4 TUBES, 560 ROUNDS.
  - 44 ARTYBN COMMANDS 443 BTY203.
    - 443 BTY203 IS AT HEX 777772522 .
    - 443 BTY203 HAS 4 TUBES, 560 ROUNDS.
- 4 DIVARTY COMMANDS 45 MISLBN.
  - 45 MISLBN COMMANDS 450 HMB.
    - 450 HMB IS AT HEX 777772571 .
    - 450 HMB HAS 1 APC, 40 ROUNDS, 16 RADIOS.
  - 45 MISLBN COMMANDS 451 HJRTY.
    - 451 HJRTY IS AT HEX 777772757 .
    - 451 HJRTY HAS 2 ROCKETS, 8 GROUNDNUKES.
  - 45 MISLBN COMMANDS 452 HJRTY.
    - 452 HJRTY IS AT HEX 777772562 .
    - 452 HJRTY HAS 2 ROCKETS, 8 GROUNDNUKES.
- 3 ARMDIV COMMANDS 5 RECBN.
  - 5 RECBN COMMANDS 50 HMC.
    - 50 HMC IS AT HEX 777772433 .
    - 50 HMC HAS 4 APC, 160 ROUNDS, 34 RADIOS.
  - 5 RECBN COMMANDS 51 RECCO.
    - 51 RECCO IS AT HEX 777776334 .
    - 51 RECCO HAS 18 APC, 9 TANKS, 1 TUBE, 1109 ROUNDS.
  - 5 RECBN COMMANDS 52 RECCO.
    - 52 RECCO IS AT HEX 777772665 .
    - 52 RECCO HAS 18 APC, 9 TANKS, 1 TUBE, 1109 ROUNDS.
  - 5 RECBN COMMANDS 53 RECCO.
    - 53 RECCO IS AT HEX 777772621 .
    - 53 RECCO HAS 18 APC, 9 TANKS, 1 TUBE, 1109 ROUNDS.
  - 5 RECBN COMMANDS 54 RECCO.
    - 54 RECCO IS AT HEX 777761115 .
    - 54 RECCO HAS 4 ATU, 63 ROUNDS.
- 3 ARMDIV COMMANDS 6 RECCO.
  - 6 RECCO IS AT HEX 777772446 .
  - 6 RECCO HAS 4 ATU, 63 ROUNDS.

WP.

RUSSIAN.

1 TA COMMANDS 10 TKDIV.

10 TKDIV COMMANDS 10 HHC.

10 HHC IS AT HEX 777761646 .

10 HHC HAS 1 ATU, 31 ROUNDS.

10 TKDIV COMMANDS 5 TKRGT.

5 TKRGT COMMANDS 50 HHC.

50 HHC IS AT HEX 777761674 .

50 HHC HAS 3 APC, 2 TANKS, 125 ROUNDS.

5 TKRGT COMMANDS 51 TKBN.

51 TKBN COMMANDS 510 HHC.

510 HHC IS AT HEX 777761675 .

510 HHC HAS 2 APC, 1 TANK, 70 ROUNDS.

51 TKBN COMMANDS 511 TKCO.

511 TKCO IS AT HEX 777761764 .

511 TKCO HAS 10 TANKS, 400 ROUNDS.

51 TKBN COMMANDS 512 TKCO.

512 TKCO IS AT HEX 777761764 .

512 TKCO HAS 10 TANKS, 400 ROUNDS.

51 TKBN COMMANDS 513 TKCO.

513 TKCO IS AT HEX 777761766 .

513 TKCO HAS 10 TANKS, 400 ROUNDS.

5 TKRGT COMMANDS 52 TKBN.

52 TKBN COMMANDS 520 HHC.

520 HHC IS AT HEX 777761652 .

520 HHC HAS 2 APC, 1 TANK, 70 ROUNDS.

52 TKBN COMMANDS 521 TKCO.

521 TKCO IS AT HEX 777761431 .

521 TKCO HAS 10 TANKS, 400 ROUNDS.

52 TKBN COMMANDS 522 TKCO.

522 TKCO IS AT HEX 777761431 .

522 TKCO HAS 10 TANKS, 400 ROUNDS.

52 TKBN COMMANDS 523 TKCO.

523 TKCO IS AT HEX 777761433 .

523 TKCO HAS 10 TANKS, 400 ROUNDS.

5 TKRGT COMMANDS 53 TKBN.

53 TKBN COMMANDS 530 HHC.

530 HHC IS AT HEX 777761641 .

530 HHC HAS 2 APC, 1 TANK, 70 ROUNDS.

53 TKBN COMMANDS 531 TKCO.

531 TKCO IS AT HEX 777761437 .

531 TKCO HAS 10 TANKS, 400 ROUNDS.

53 TKBN COMMANDS 532 TKCO.

532 TKCO IS AT HEX 777761437 .

532 TKCO HAS 10 TANKS, 400 ROUNDS.

53 TKBN COMMANDS 533 TKCO.

533 TKCO IS AT HEX 777761432 .

533 TKCO HAS 10 TANKS, 400 ROUNDS.

5 TKRGT COMMANDS 541 TKCO.

541 TKCO IS AT HEX 777761473 .

541 TKCO HAS 10 TANKS, 400 ROUNDS.

5 TKRGT COMMANDS 551 CO.

551 CO IS AT HEX 777761473 .

551 CO HAS 6 ATU, 91 ROUNDS.

10 TKDIV COMMANDS 6 TKRGT.  
   6 TKRGT COMMANDS 60 HHC.  
     60 HHC IS AT HEX 777765317 .  
     60 HHC HAS 3 APC, 2 TANKS, 125 ROUNDS.  
   6 TKRGT COMMANDS 61 TKBN.  
     61 TKBN COMMANDS 610 HHC.  
       610 HHC IS AT HEX 777765317 .  
       610 HHC HAS 2 APC, 1 TANK, 70 ROUNDS.  
     61 TKBN COMMANDS 611 TKCO.  
       611 TKCO IS AT HEX 777761476 .  
       611 TKCO HAS 10 TANKS, 400 ROUNDS.  
     61 TKBN COMMANDS 612 TKCO.  
       612 TKCO IS AT HEX 777761476 .  
       612 TKCO HAS 10 TANKS, 400 ROUNDS.  
     61 TKBN COMMANDS 613 TKCO.  
       613 TKCO IS AT HEX 777761461 .  
       613 TKCO HAS 10 TANKS, 400 ROUNDS.  
   6 TKRGT COMMANDS 62 TKBN.  
     62 TKBN COMMANDS 620 HHC.  
       620 HHC IS AT HEX 777765314 .  
       620 HHC HAS 2 APC, 1 TANK, 70 ROUNDS.  
     62 TKBN COMMANDS 621 TKCO.  
       621 TKCO IS AT HEX 777761442 .  
       621 TKCO HAS 10 TANKS, 400 ROUNDS.  
     62 TKBN COMMANDS 622 TKCO.  
       622 TKCO IS AT HEX 777761442 .  
       622 TKCO HAS 10 TANKS, 400 ROUNDS.  
     62 TKBN COMMANDS 623 TKCO.  
       623 TKCO IS AT HEX 777761465 .  
       623 TKCO HAS 10 TANKS, 400 ROUNDS.  
   6 TKRGT COMMANDS 63 TKBN.  
     63 TKBN COMMANDS 630 HHC.  
       630 HHC IS AT HEX 777765316 .  
       630 HHC HAS 2 APC, 1 TANK, 70 ROUNDS.  
     63 TKBN COMMANDS 631 TKCO.  
       631 TKCO IS AT HEX 777761442 .  
       631 TKCO HAS 10 TANKS, 400 ROUNDS.  
     63 TKBN COMMANDS 632 TKCO.  
       632 TKCO IS AT HEX 777761442 .  
       632 TKCO HAS 10 TANKS, 400 ROUNDS.  
     63 TKBN COMMANDS 633 TKCO.  
       633 TKCO IS AT HEX 777761464 .  
       633 TKCO HAS 10 TANKS, 400 ROUNDS.  
   6 TKRGT COMMANDS 641 TKCO.  
     641 TKCO IS AT HEX 777761472 .  
     641 TKCO HAS 10 TANKS, 400 ROUNDS.  
   6 TKRGT COMMANDS 651 CO.  
     651 CO IS AT HEX 777761472 .  
     651 CO HAS 6 ATU, 91 ROUNDS.

1 TA COMMANDS 9 TKDIV.  
   9 TKDIV COMMANDS 9 HHC.  
     9 HHC IS AT HEX 777761436 .  
     9 HHC HAS 1 ATU, 31 ROUNDS.  
   9 TKDIV COMMANDS 1 TKRGT.  
     1 TKRGT COMMANDS 10 HHC.  
       10 HHC IS AT HEX 777761415 .  
       10 HHC HAS 3 APC, 2 TANKS, 125 ROUNDS.  
     1 TKRGT COMMANDS 11 TKHN.  
       11 TKHN COMMANDS 110 HHC.  
         110 HHC IS AT HEX 777776217 .  
         110 HHC HAS 2 APC, 1 TANK, 70 ROUNDS.  
       11 TKHN COMMANDS 111 TKCO.  
         111 TKCO IS AT HEX 777776361 .  
         111 TKCO HAS 10 TANKS, 400 ROUNDS.  
       11 TKHN COMMANDS 112 TKCO.  
         112 TKCO IS AT HEX 777776361 .  
         112 TKCO HAS 10 TANKS, 400 ROUNDS.  
       11 TKHN COMMANDS 113 TKCO.  
         113 TKCO IS AT HEX 777776324 .  
         113 TKCO HAS 10 TANKS, 400 ROUNDS.  
     1 TKRGT COMMANDS 12 TKHN.  
       12 TKHN COMMANDS 120 HHC.  
         120 HHC IS AT HEX 777761544 .  
         120 HHC HAS 2 APC, 1 TANK, 70 ROUNDS.  
       12 TKHN COMMANDS 121 TKCO.  
         121 TKCO IS AT HEX 777776325 .  
         121 TKCO HAS 10 TANKS, 400 ROUNDS.  
       12 TKHN COMMANDS 122 TKCO.  
         122 TKCO IS AT HEX 777776325 .  
         122 TKCO HAS 10 TANKS, 400 ROUNDS.  
       12 TKHN COMMANDS 123 TKCO.  
         123 TKCO IS AT HEX 777776321 .  
         123 TKCO HAS 10 TANKS, 400 ROUNDS.  
     1 TKRGT COMMANDS 13 TKHN.  
       13 TKHN COMMANDS 130 HHC.  
         130 HHC IS AT HEX 777761541 .  
         130 HHC HAS 2 APC, 1 TANK, 70 ROUNDS.  
       13 TKHN COMMANDS 131 TKCO.  
         131 TKCO IS AT HEX 777761554 .  
         131 TKCO HAS 10 TANKS, 400 ROUNDS.  
       13 TKHN COMMANDS 132 TKCO.  
         132 TKCO IS AT HEX 777761555 .  
         132 TKCO HAS 10 TANKS, 400 ROUNDS.  
       13 TKHN COMMANDS 133 TKCO.  
         133 TKCO IS AT HEX 777761555 .  
         133 TKCO HAS 10 TANKS, 400 ROUNDS.  
     1 TKRGT COMMANDS 141 TKCO.  
       141 TKCO IS AT HEX 777776332 .  
       141 TKCO HAS 10 TANKS, 400 ROUNDS.  
     1 TKRGT COMMANDS 151 CO.  
       151 CO IS AT HEX 777776332 .  
       151 CO HAS 6 ATU, 91 ROUNDS.

9 TKDIV COMMANDS 2 MRRGT.  
   2 MRRGT COMMANDS 20 HHC.  
     20 HHC IS AT HEX 777761411 .  
     20 HHC HAS 6 APC, 91 ROUNDS.  
   2 MRRGT COMMANDS 21 MRBN.  
     21 MRBN COMMANDS 210 HHC.  
       210 HHC IS AT HEX 777761572 .  
       210 HHC HAS 1 APC, 31 ROUNDS.  
     21 MRBN COMMANDS 211 MRCO.  
       211 MRCO IS AT HEX 777772666 .  
       211 MRCO HAS 9 APC, 86 ROUNDS.  
     21 MRBN COMMANDS 212 MRCO.  
       212 MRCO IS AT HEX 777772666 .  
       212 MRCO HAS 9 APC, 86 ROUNDS.  
     21 MRBN COMMANDS 213 MRCO.  
       213 MRCO IS AT HEX 777761551 .  
       213 MRCO HAS 9 APC, 86 ROUNDS.  
     21 MRBN COMMANDS 214 BTY.  
       214 BTY IS AT HEX 777761551 .  
       214 BTY HAS 2 TUBES, 238 ROUNDS.  
     21 MRBN COMMANDS 215 MCSCO.  
       215 MCSCO IS AT HEX 777761553 .  
       215 MCSCO HAS 6 ATU, 58 ROUNDS.  
   2 MRRGT COMMANDS 22 MRBN.  
     22 MRBN COMMANDS 220 HHC.  
       220 HHC IS AT HEX 777761536 .  
       220 HHC HAS 1 APC 31 ROUNDS.  
     22 MRBN COMMANDS 221 MRCO.  
       221 MRCO IS AT HEX 777772662 .  
       221 MRCO HAS 9 APC, 86 ROUNDS.  
     22 MRBN COMMANDS 222 MRCO.  
       222 MRCO IS AT HEX 777772662 .  
       222 MRCO HAS 9 APC, 86 ROUNDS.  
     22 MRBN COMMANDS 223 MRCO.  
       223 MRCO IS AT HEX 777761514 .  
       223 MRCO HAS 9 APC, 86 ROUNDS.  
     22 MRBN COMMANDS 224 BTY.  
       224 BTY IS AT HEX 777761514 .  
       224 BTY HAS 2 TUBES, 238 ROUNDS.  
     22 MRBN COMMANDS 225 MCSCO.  
       225 MCSCO IS AT HEX 777761516 .  
       225 MCSCO HAS 6 ATU, 58 ROUNDS.  
   2 MRRGT COMMANDS 23 MRBN.  
     23 MRBN COMMANDS 230 HHC.  
       230 HHC IS AT HEX 777761533 .  
       230 HHC HAS 1 APC, 31 ROUNDS.  
     23 MRBN COMMANDS 231 MRCO.  
       231 MRCO IS AT HEX 777772626 .  
       231 MRCO HAS 9 APC, 86 ROUNDS.  
     23 MRBN COMMANDS 232 MRCO.  
       232 MRCO IS AT HEX 777772626 .  
       232 MRCO HAS 9 APC, 86 ROUNDS.  
     23 MRBN COMMANDS 233 MRCO.  
       233 MRCO IS AT HEX 777761511 .  
       233 MRCO HAS 9 APC, 86 ROUNDS.  
     23 MRBN COMMANDS 234 BTY.  
       234 BTY IS AT HEX 777772622 .  
       234 BTY HAS 2 TUBES, 238 ROUNDS.  
     23 MRBN COMMANDS 235 MCSCO.  
       235 MCSCO IS AT HEX 777772622 .  
       235 MCSCO HAS 6 ATU, 58 ROUNDS.



2 MRRGT COMMANDS 24 TKBN.  
 24 TKBN COMMANDS 240 HHC.  
 240 HHC IS AT HEX 777761537 .  
 240 HHC HAS 3 APC, 2 TANKS, 125 ROUNDS.  
 24 TKBN COMMANDS 241 TKCO.  
 241 TKCO IS AT HEX 777761515 .  
 241 TKCO HAS 10 TANKS, 400 ROUNDS.  
 24 TKBN COMMANDS 242 TKCO.  
 242 TKCO IS AT HEX 777761515 .  
 242 TKCO HAS 10 TANKS, 400 ROUNDS.  
 24 TKBN COMMANDS 243 TKCO.  
 243 TKCO IS AT HEX 777761517 .  
 243 TKCO HAS 10 TANKS, 400 ROUNDS.  
 2 MRRGT COMMANDS 25 ARTYBN.  
 25 ARTYBN COMMANDS 250 HHB.  
 250 HHB IS AT HEX 777761525 .  
 250 HHB HAS 1 APC, 31 ROUNDS.  
 25 ARTYBN COMMANDS 251 MCSCO.  
 251 MCSCO IS AT HEX 777761512 .  
 251 MCSCO HAS 6 ATU, 90 ROUNDS.  
 25 ARTYBN COMMANDS 252 MCSCO.  
 252 MCSCO IS AT HEX 777761517 .  
 252 MCSCO HAS 6 ATU, 90 ROUNDS.  
 25 ARTYBN COMMANDS 253 BTY.  
 253 BTY IS AT HEX 777761513 .  
 253 BTY HAS 6 TUBES, 708 ROUNDS.  
 9 TKDIV COMMANDS 3 ACS.  
 3 ACS COMMANDS 30 HHC.  
 30 HHC IS AT HEX 777761574 .  
 30 HHC HAS 2 ATU, 30 ROUNDS.  
 3 ACS COMMANDS 31 ACT.  
 31 ACT IS AT HEX 777776376 .  
 31 ACT HAS 2 ATU, 3 TANKS, 300 ROUNDS.  
 3 ACS COMMANDS 32 ACT.  
 32 ACT IS AT HEX 777776373 .  
 32 ACT HAS 2 ATU, 3 TANKS, 300 ROUNDS.  
 3 ACS COMMANDS 33 ACT.  
 33 ACT IS AT HEX 777776337 .  
 33 ACT HAS 2 ATU, 3 TANKS, 300 ROUNDS.  
 3 ACS COMMANDS 34 ACT.  
 34 ACT IS AT HEX 777772664 .  
 34 ACT HAS 2 ATU, 3 TANKS, 300 ROUNDS.  
 3 ACS COMMANDS 35 ACT.  
 35 ACT IS AT HEX 777772624 .  
 35 ACT HAS 2 ATU, 3 TANKS, 300 ROUNDS.

9 TKDIV COMMANDS 4 ARTYBDE.

- 4 ARTYBDE COMMANDS 40 HHB.
  - 40 HHB IS AT HEX 777761747 .
  - 40 HHB HAS 2 APC, 31 ROUNDS.
- 4 ARTYBDE COMMANDS 41 ARTYBN.
  - 41 ARTYBN COMMANDS 410 HHB.
    - 410 HHB IS AT HEX 777761754 .
    - 410 HHB HAS 1 APC, 31 ROUNDS.
  - 41 ARTYBN COMMANDS 411 BTY.
    - 411 BTY IS AT HEX 777761144 .
    - 411 BTY HAS 2 TUBES, 450 ROUNDS.
  - 41 ARTYBN COMMANDS 412 BTY.
    - 412 BTY IS AT HEX 777761144 .
    - 412 BTY HAS 2 TUBES, 450 ROUNDS.
  - 41 ARTYBN COMMANDS 413 BTY.
    - 413 BTY IS AT HEX 777761513 .
    - 413 BTY HAS 2 TUBES, 450 ROUNDS.
- 4 ARTYBDE COMMANDS 42 ARTYBN.
  - 42 ARTYBN COMMANDS 420 HHB.
    - 420 HHB IS AT HEX 777761522 .
    - 420 HHB HAS 1 APC, 31 ROUNDS.
  - 42 ARTYBN COMMANDS 421 BTY.
    - 421 BTY IS AT HEX 777761553 .
    - 421 BTY HAS 2 TUBES, 450 ROUNDS.
  - 42 ARTYBN COMMANDS 422 BTY.
    - 422 BTY IS AT HEX 777761516 .
    - 422 BTY HAS 2 TUBES, 450 ROUNDS.
  - 42 ARTYBN COMMANDS 423 BTY.
    - 423 BTY IS AT HEX 777761512 .
    - 423 BTY HAS 2 TUBES, 430 ROUNDS.
- 4 ARTYBDE COMMANDS 43 ARTYBN.
  - 43 ARTYBN COMMANDS 430 HHB.
    - 430 HHB IS AT HEX 777761524 .
    - 430 HHB HAS 1 APC, 31 ROUNDS.
  - 43 ARTYBN COMMANDS 431 BTY.
    - 431 BTY IS AT HEX 777761511 .
    - 431 BTY HAS 4 TUBES, 400 ROUNDS.
  - 43 ARTYBN COMMANDS 432 BTY.
    - 432 BTY IS AT HEX 777761534 .
    - 432 BTY HAS 4 TUBES, 400 ROUNDS.
  - 43 ARTYBN COMMANDS 433 BTY.
    - 433 BTY IS AT HEX 777761534 .
    - 433 BTY HAS 4 TUBES, 400 ROUNDS.
- 4 ARTYBDE COMMANDS 44 ARTYBN.
  - 44 ARTYBN COMMANDS 440 HHB.
    - 440 HHB IS AT HEX 777761521 .
    - 440 HHB HAS 1 APC, 31 ROUNDS.
  - 44 ARTYBN COMMANDS 441 BTY203.
    - 441 BTY203 IS AT HEX 777761146 .
    - 441 BTY203 HAS 4 TUBES, 400 ROUNDS.
  - 44 ARTYBN COMMANDS 442 BTY203.
    - 442 BTY203 IS AT HEX 777761535 .
    - 442 BTY203 HAS 4 TUBES, 400 ROUNDS.
  - 44 ARTYBN COMMANDS 443 BTY203.
    - 443 BTY203 IS AT HEX 777761535 .
    - 443 BTY203 HAS 4 TUBES, 400 ROUNDS.

9 TKDIV COMMANDS 7 DIVARTY.  
 7 DIVARTY COMMANDS 70 HHB.  
 70 HHB IS AT HEX 777776223 .  
 70 HHB HAS 2 APC, 31 ROUNDS.  
 7 DIVARTY COMMANDS 71 ARTYBN.  
 71 ARTYBN COMMANDS 710 HHB.  
 710 HHB IS AT HEX 777776234 .  
 710 HHB HAS 2 APC, 31 ROUNDS.  
 71 ARTYBN COMMANDS 711 BTY122.  
 711 BTY122 IS AT HEX 777776363 .  
 711 BTY122 HAS 6 TUBES, 471 ROUNDS.  
 71 ARTYBN COMMANDS 712 BTY122.  
 712 BTY122 IS AT HEX 777776363 .  
 712 BTY122 HAS 6 TUBES, 471 ROUNDS.  
 71 ARTYBN COMMANDS 713 BTY122.  
 713 BTY122 IS AT HEX 777776324 .  
 713 BTY122 HAS 6 TUBES, 471 ROUNDS.  
 7 DIVARTY COMMANDS 72 ARTYBN.  
 72 ARTYBN COMMANDS 720 HHB.  
 720 HHB IS AT HEX 777776231 .  
 720 HHB HAS 2 APC, 31 ROUNDS.  
 72 ARTYBN COMMANDS 721 BTY122.  
 721 BTY122 IS AT HEX 777776321 .  
 721 BTY122 HAS 6 TUBES, 471 ROUNDS.  
 72 ARTYBN COMMANDS 722 BTY122.  
 722 BTY122 IS AT HEX 777776323 .  
 722 BTY122 HAS 6 TUBES, 471 ROUNDS.  
 72 ARTYBN COMMANDS 723 BTY122.  
 723 BTY122 IS AT HEX 777776323 .  
 723 BTY122 HAS 6 TUBES, 471 ROUNDS.  
 7 DIVARTY COMMANDS 73 MRLBN.  
 73 MRLBN COMMANDS 730 HHB.  
 730 HHB IS AT HEX 777776235 .  
 730 HHB HAS 2 APC, 31 ROUNDS.  
 73 MRLBN COMMANDS 731 MRLBTY.  
 731 MRLBTY IS AT HEX 777776327 .  
 731 MRLBTY HAS 6 TUBES, 1184 ROUNDS.  
 73 MRLBN COMMANDS 732 MRLBTY.  
 732 MRLBTY IS AT HEX 777776327 .  
 732 MRLBTY HAS 6 TUBES, 1184 ROUNDS.  
 73 MRLBN COMMANDS 733 MRLBTY.  
 733 MRLBTY IS AT HEX 777761554 .  
 733 MRLBTY HAS 6 TUBES, 1184 ROUNDS.  
 7 DIVARTY COMMANDS 74 MRLBN.  
 74 MRLBN COMMANDS 740 HHB.  
 740 HHB IS AT HEX 777761562 .  
 740 HHB HAS 2 APC, 31 ROUNDS.  
 74 MRLBN COMMANDS 741 FROGBTY.  
 741 FROGBTY IS AT HEX 777761571 .  
 741 FROGBTY HAS 2 ROCKETS, 8 GROUNDNUKES.  
 74 MRLBN COMMANDS 742 FROGBTY.  
 742 FROGBTY IS AT HEX 777761557 .  
 742 FROGBTY HAS 2 ROCKETS, 8 GROUNDNUKES.

9 TKDIV COMMANDS 8 RECRGT.  
   8 RECRGT COMMANDS 80 HHC.  
     80 HHC IS AT HEX 777761562 .  
     80 HHC HAS 1 ATU, 31 ROUNDS.  
   8 RECRGT COMMANDS 81 RECBN.  
     81 RECBN COMMANDS 810 HHC.  
       810 HHC IS AT HEX 777761556 .  
       810 HHC HAS 1 ATU, 31 ROUNDS.  
     81 RECBN COMMANDS 811 RECCO.  
       811 RECCO IS AT HEX 777761556 .  
       811 RECCO HAS 1 ATU, 31 ROUNDS.  
     81 RECBN COMMANDS 812 RECCO.  
       812 RECCO IS AT HEX 777776215 .  
       812 RECCO HAS 1 ATU, 31 ROUNDS.  
     81 RECBN COMMANDS 813 RECCO.  
       813 RECCO IS AT HEX 777761511 .  
       813 RECCO HAS 1 ATU, 31 ROUNDS.  
     81 RECBN COMMANDS 814 RECCO.  
       814 RECCO IS AT HEX 777776322 .  
       814 RECCO HAS 1 ATU, 31 ROUNDS.  
     81 RECBN COMMANDS 815 RECCO.  
       815 RECCO IS AT HEX 777761553 .  
       815 RECCO HAS 1 ATU, 31 ROUNDS.  
   8 RECRGT COMMANDS 82 RECBN.  
     82 RECBN COMMANDS 820 HHC.  
       820 HHC IS AT HEX 777767477 .  
       820 HHC HAS 1 ATU, 31 ROUNDS.  
     82 RECBN COMMANDS 821 RECCO.  
       821 RECCO IS AT HEX 777761456 .  
       821 RECCO HAS 1 ATU, 31 ROUNDS.  
     82 RECBN COMMANDS 822 RECCO.  
       822 RECCO IS AT HEX 777767737 .  
       822 RECCO HAS 1 ATU, 31 ROUNDS.  
     82 RECBN COMMANDS 823 RECCO.  
       823 RECCO IS AT HEX 777764117 .  
       823 RECCO HAS 1 ATU, 31 ROUNDS.  
     82 RECBN COMMANDS 824 RECCO.  
       824 RECCO IS AT HEX 777761562 .  
       824 RECCO HAS 1 ATU, 31 ROUNDS.  
     82 RECBN COMMANDS 825 RECCO.  
       825 RECCO IS AT HEX 777761451 .  
       825 RECCO HAS 1 ATU, 31 ROUNDS.

#### PART IV

MITL INITIAL ORDERS (OPORDS). THE MITL ROUTINES ARE SET UP TO BE INTERACTIVE. THOSE LINES WITH A SQUARE (□) NEXT TO THEM ARE USER INPUTS. THE OTHERS ARE COMPUTER RESPONSES.

ENTER TIME POINT TO HOOK ORDERS TO  
(ENTER TIME IN SECONDS)

■0

01/03/79

09.00.09.

MAN-IN-LOOP OPORD INPUT

ENTER LEVEL FOR INSTRUCTION(FULL/PARTIAL)

■FULL

ENTER LENGTH OF NEXT RUN(MINUTES)

■72000

WHICH SIDE (RED/BLUE/NONE) FOR NUCLEAR STRIKE

NONE

WHICH SIDE (RED/BLUE/NONE)

■RED

ENTER UNIT TO BE MOVED

INPUT UNIT DESIGNATION:

CORPS/CAA,DIV,BDE/REG,BN

WITH ZERO (0) WHERE NO UNIT AT THAT ECHELON

■1 9 7 0

ENTER OLD COMMANDER

INPUT UNIT DESIGNATION:

CORPS/CAA,DIV,BDE/REG,BN

WITH ZERO (0) WHERE NO UNIT AT THAT ECHELON

■1 9 0 0

ENTER NEW COMMANDER

INPUT UNIT DESIGNATION:

CORPS/CAA,DIV,BDE/REG,BN

WITH ZERO (0) WHERE NO UNIT AT THAT ECHELON

■1 10 0 0

ENTER EFFECTIVE TIME (IN SECONDS) OF GAME

■10600

REVIEWING WHAT YOU HAVE ENTERED

DO YOU WANT TO USE THIS REASSIGNMENT (YES/NO)

■YES

WHICH SIDE (RED/BLUE/NONE)

■NONE

WHICH SIDE (RED/BLUE/NONE)

■RED

INPUT UNIT DESIGNATION:

CORPS/CAA,DIV,BDE/REG,BN

WITH ZERO (0) WHERE NO UNIT AT THAT ECHELON

■1 9 0 0

INPUT OPERATION(ATK/DEF)

■ATK

INPUT INITIAL,FINAL TIMES AS INTEGER DHHMM

■10000 11200

INPUT GS PRIORITY AS INTEGER PERCENT

■50

ARE NUCLEAR WEAPONS PERMITTED

■YES

INPUT ACCEPTABLE CASUALTY LIMIT, AND  
 MIN SUPPLY LEVEL AS INTEGER PERCENTS  
 INPUT MIN,MAX SPEED LIMITS AS INTEGER PERCENT  
 OF UNIT THEORETICAL BEST SPEED  
 ■ 90 5 90 10  
 INPUT LEFT BOUNDARY HEXES (AS FACE DIRECTION OF MOVEMENT)  
 REAR TO FRONT, FOLLOWED BY ZERO (0)  
 THEN RIGHT BOUNDARY HEXES-REAR TO FRONT  
 TERMINATE LIST BY A NINE (9)  
 ■ 777761446  
 ■ 777776343  
 ■ 777776351  
 ■ 777772441  
 ■ 777772454  
 ■ 777772564  
 ■ 777772515  
 ■ 0  
 ■ 777761632  
 ■ 777772623  
 ■ 777772625  
 ■ 7777724422  
 ■ 777772436  
 ■ 777772715  
 ■ 777772113  
 ■ 9  
 DO YOU NEED INSTRUCTIONS FOR INPUT OF PHASE LINES (YES/NO)  
 ■ NO  
 INPUT OPERATION CODE (0 TO TERMINATE), AS INTEGER, END TIME  
 OF PHASE AS INTEGER DHHMM  
 ■ 2 10200  
 INPUT HEX LIST AS INTEGERS  
 ■ 777776351  
 ■ 777772467  
 ■ 777772472  
 ■ 777776313  
 ■ 777772625  
 ■ 9  
 INPUT OPERATION CODE (0 TO TERMINATE), AS INTEGER, END TIME  
 OF PHASE AS INTEGER DHHMM  
 ■ 2 10400  
 INPUT HEX LIST AS INTEGERS  
 ■ 777772441  
 ■ 777772475  
 ■ 777772417  
 ■ 777772434  
 ■ 777772436  
 ■ 9  
 INPUT OPERATION CODE (0 TO TERMINATE), AS INTEGER, END TIME  
 OF PHASE AS INTEGER DHHMM  
 ■ 2 10600  
 INPUT HEX LIST AS INTEGERS  
 ■ 777772564  
 ■ 777772527  
 ■ 777772757  
 ■ 777772715  
 ■ 9

INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME  
OF PHASE AS INTEGER DHHMM  
■ 0 0  
END OF PHASE INPUT FOR THIS UNIT

INPUT ORDERS FOR UNIT 4523  
( 1, 9, 0, 0)

OPERATION: ATK START: 10000 STOP: 11200  
MIN SPEED: 90% MAX SPEED: 10%  
MAX CASUALTIES: 90% MIN SUPPLIES: 5%  
LEFT BOUNDARY:

777761446  
777776343  
777776351  
777772441  
777772454  
777772564  
777772515

RIGHT BOUNDARY:

777761632  
777772623  
777772625  
7777724422  
777772436  
777772715  
777772113

PHASE NUMBER: 1  
TYPE PHASE: 2 END OF PHASE: 10200  
PHASELINE:

777776351  
777772467  
777772472  
777776313  
777772625

PHASE NUMBER: 2  
TYPE PHASE: 2 END OF PHASE: 10400  
PHASELINE:

777772441  
777772475  
777772417  
777772434  
777772436

PHASE NUMBER: 3  
TYPE PHASE: 2 END OF PHASE: 10600  
PHASELINE:

777772564  
777772527  
777772757  
777772715

DO YOU WANT TO USE THE LAST OPORD (YES/NO)  
■ YES



WHICH SIDE (RED/BLUE/NONE)

■ RED  
 INPUT UNIT DESIGNATION:  
 CORPS/CAA,DIV,BDE/REG,BN  
 WITH ZERO (0) WHERE NO UNIT AT THAT ECHELON

■ 1 10 0 0  
 INPUT OPERATION(ATK/DEF)

■ ATK  
 INPUT INITIAL,FINAL TIMES AS INTEGER DHMM

■ 10000 11200  
 INPUT GS PRIORITY AS INTEGER PERCENT

■ 50  
 ARE NUCLEAR WEAPONS PERMITTED

■ YES  
 INPUT ACCEPTABLE CASUALTY LIMIT, AND  
 MIN SUPPLY LEVEL AS INTEGER PERCENTS  
 INPUT MIN,MAX SPEED LIMITS AS INTEGER PERCENT  
 OF UNIT THEORETICAL BEST SPEED

■ 90 5 90 10  
 INPUT LEFT BOUNDARY HEXES(AS FACE DIRECTION OF MOVEMENT)  
 REAR TO FRONT,FOLLOWED BY ZERO(0)  
 THEN RIGHT BOUNDARY HEXES-REAR TO FRONT  
 TERMINATE LIST BY A NINE (9)

■ 777761466  
 ■ 777776343  
 ■ 777776316  
 ■ 777772422  
 ■ 777772436  
 ■ 777772431  
 ■ 777772142  
 ■ 777772155  
 ■ 0  
 ■ 777761632  
 ■ 777772623  
 ■ 777772276  
 ■ 777772257  
 ■ 777772125  
 ■ 777772113  
 ■ 9

DO YOU NEED INSTRUCTIONS FOR INPUT OF PHASELINES(YES/NO)

■ NO  
 INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME  
 OF PHASE AS INTEGER DHMM

■ 2 10530  
 INPUT HEX LIST AS INTEGERS

■ 777776343  
 ■ 777772664  
 ■ 777772623  
 ■ 9

INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME  
 OF PHASE AS INTEGER DHMM

■ 2 10730  
 INPUT HEX LIST AS INTEGERS

■ 777776316  
 ■ 777772643  
 ■ 777772244  
 ■ 777772276  
 ■ 9

INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME  
 OF PHASE AS INTEGER DHMM

■ 2 10930  
 INPUT HEX LIST AS INTEGERS

■777772431  
■777772775  
■777772257  
■9

INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME  
OF PHASE AS INTEGER DHHMM

■2 11130

INPUT HEX LIST AS INTEGERS

■777772142  
■777772177  
■777772125

■9

INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME  
OF PHASE AS INTEGER DHHMM

■0 0

END OF PHASE INPUT FOR THIS UNIT

INPUT ORDERS FOR UNIT 3413  
( 1, 10, 0, 0)

OPERATION: ATK START: 10000 STOP: 11200  
MIN SPEED: 90% MAX SPEED: 10%  
MAX CASUALTIES: 90% MIN SUPPLIES: 5%  
LEFT BOUNDARY:

777761446  
77776343  
77776316  
777772422  
777772436  
777772431  
777772142  
777772155

RIGHT BOUNDARY:

777761632  
777772623  
777772276  
777772257  
777772125  
777772113

PHASE NUMBER: 1

TYPE PHASE: 2 END OF PHASE: 10530

PHASELINE:

777776343  
777772664  
777772623

PHASE NUMBER: 2

TYPE PHASE: 2 END OF PHASE: 10730

PHASELINE:

777776316  
777772643  
777772244  
777772276

PHASE NUMBER: 3  
TYPE PHASE: 2      END OF PHASE: 10930  
PHASELINE:

777772431  
777772775  
777772257

PHASE NUMBER: 4  
TYPE PHASE: 2      END OF PHASE: 11130  
PHASELINE:

777772142  
777772177  
777772125

DO YOU WANT TO USE THE LAST OPORD (YES/NO)

■ YES

WHICH SIDE (RED/BLUE/NONE)

■ BLUE

INPUT UNIT DESIGNATION:  
CORPS/CAA, DIV, BDE/REG, BN  
WITH ZERO (0) WHERE NO UNIT AT THAT ECHELON

■ 5 3 0 0

INPUT OPERATION (ATK/DEF)

■ DEF

INPUT INITIAL, FINAL TIMES AS INTEGER DHHMM

■ 10100 20000

INPUT GS PRIORITY AS INTEGER PERCENT

■ 50

ARE NUCLEAR WEAPONS PERMITTED

■ YES

INPUT ACCEPTABLE CASUALTY LIMIT, AND  
MIN SUPPLY LEVEL AS INTEGER PERCENTS  
INPUT MIN, MAX SPEED LIMITS AS INTEGER PERCENT  
OF UNIT THEORETICAL BEST SPEED

■ 60 40 20 70

INPUT LEFT BOUNDARY HEXES (AS FACE DIRECTION OF MOVEMENT)  
REAR TO FRONT, FOLLOWED BY ZERO (0)  
THEN RIGHT BOUNDARY HEXES-REAR TO FRONT  
TERMINATE LIST BY A NINE (9)

■ 777772133

■ 777772342

■ 777772241

■ 777772633

■ 777761577

■ 0

■ 777772515

■ 777772572

■ 777772476

■ 777776351

■ 777776255

■ 9

DO YOU NEED INSTRUCTIONS FOR INPUT OF PHASELINES(YES/NO)

■YES

YOU WILL BE ASKED TO INPUT AN OPERATION TYPE NUMBER  
FOR EACH PHASE. THE CODES REFER TO THE FOLLOWING:

| CODE | OFFENSIVE       | DEFENSIVE     |
|------|-----------------|---------------|
| 1    | MOVE TO CONTACT | HOLD POSITION |
| 2    | BRKTHRU         | DELAY         |
| 3    | HOLDING ATK     | SCREEN,MOVE   |
| 4    | EXPLOIT         | COUNTERATK    |
| 5    | RESERVE         | RESERVE       |

FOR THE PHASELINES, INPUT THE HEXES FROM LEFT TO RIGHT, MAKING  
SURE TO INCLUDE A HEX FROM THE LEFT AND RIGHT BOUNDARIES.  
TO TERMINATE HEXES, TYPE IN 9

INPUT OPERATION CODE(0 TO TERMINATE), AS INTEGER, END TIME  
OF PHASE AS INTEGER DHHMM

■3 10230

INPUT HEX LIST AS INTEGERS

■777772633

■777772624

■777776337

■777776351

■9

INPUT OPERATION CODE(0 TO TERMINATE), AS INTEGER, END TIME  
OF PHASE AS INTEGER DHHMM

■3 10530

INPUT HEX LIST AS INTEGERS

■777772241

■777772615

■777772655

■777772476

■9

INPUT OPERATION CODE(0 TO TERMINATE), AS INTEGER, END TIME  
OF PHASE AS INTEGER DHHMM

■3 10830

INPUT HEX LIST AS INTEGERS

■777772342

■777772716

■777772757

■777772572

■9

INPUT OPERATION CODE(0 TO TERMINATE), AS INTEGER, END TIME  
OF PHASE AS INTEGER DHHMM

■0 0

END OF PHASE INPUT FOR THIS UNIT

INPUT ORDERS FOR UNIT 219  
( 5, 3, 0, 0)

OPERATION: DEF START: 10100 STOP: 20000  
MIN SPEED: 20% MAX SPEED: 70%  
MAX CASUALTIES: 60% MIN SUPPLIES: 40%  
LEFT BOUNDARY:

777772133  
777772342  
777772241  
777772633  
777761577

RIGHT BOUNDARY:

777772515  
777772572  
777772476  
777776351  
777776255

PHASE NUMBER: 1

TYPE PHASE: 3 END OF PHASE: 10230

PHASELINE:

777772633  
777772624  
777776337  
777776351

PHASE NUMBER: 2

TYPE PHASE: 3 END OF PHASE: 10530

PHASELINE:

777772241  
777772615  
777772655  
777772476

PHASE NUMBER: 3

TYPE PHASE: 3 END OF PHASE: 10830

PHASELINE:

777772342  
777772716  
777772757  
777772572

DO YOU WANT TO USE THE LAST OPORD (YES/NO)

■ YES

WHICH SIDE (RED/BLUE/NONE)

■ NONE

ENTER SIDE FOR JAMMING SUPPORT  
(RED/BLUE/NONE)

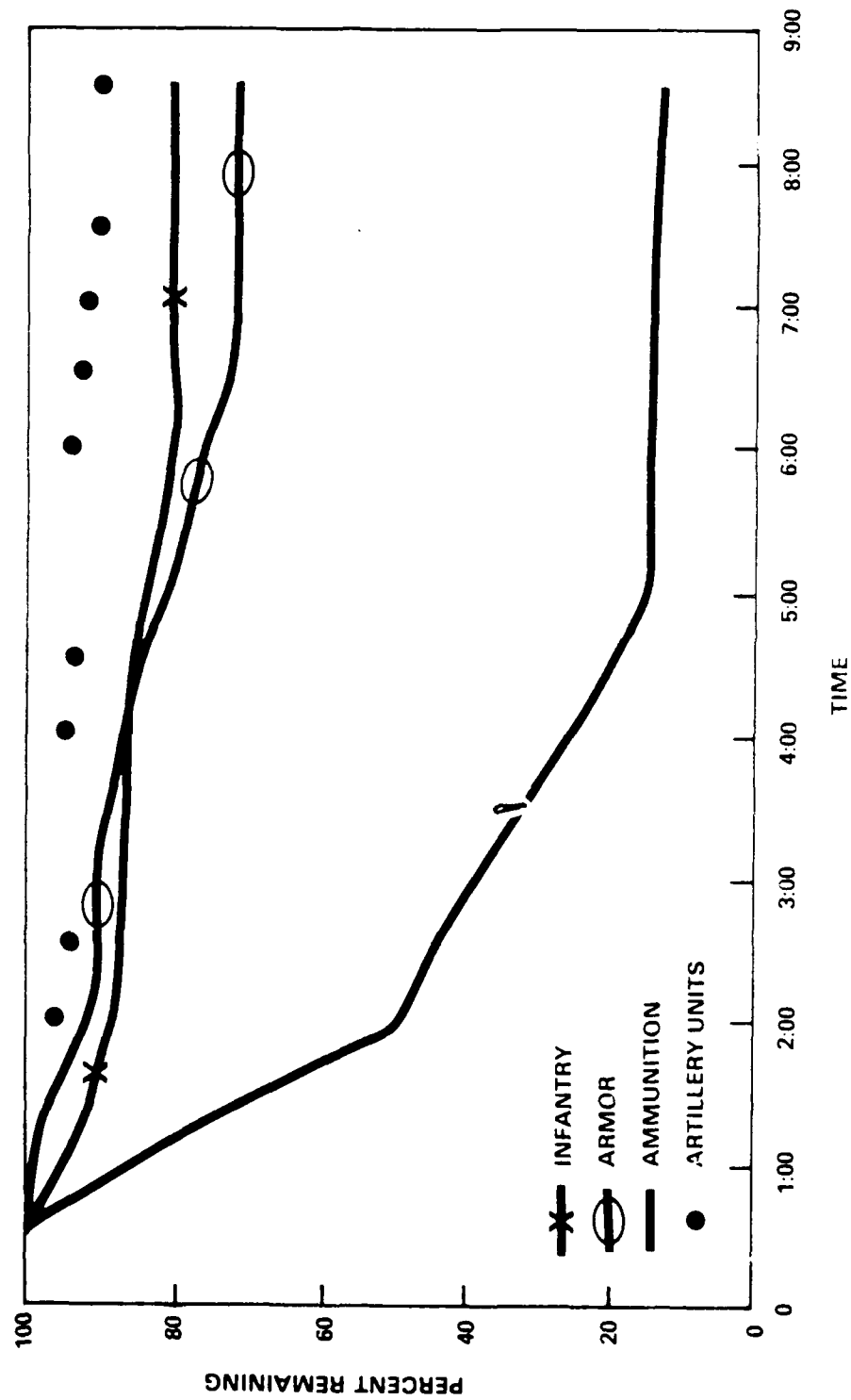
■ NONE

APPENDIX D  
BLUE DIVISION RESOURCE DRAWDOWN

Expendable combat resources in the TRACE model are: armor units, infantry units, artillery units, and ammunition. The six charts in this appendix show the dynamic drawdown of those resources for the Blue player.

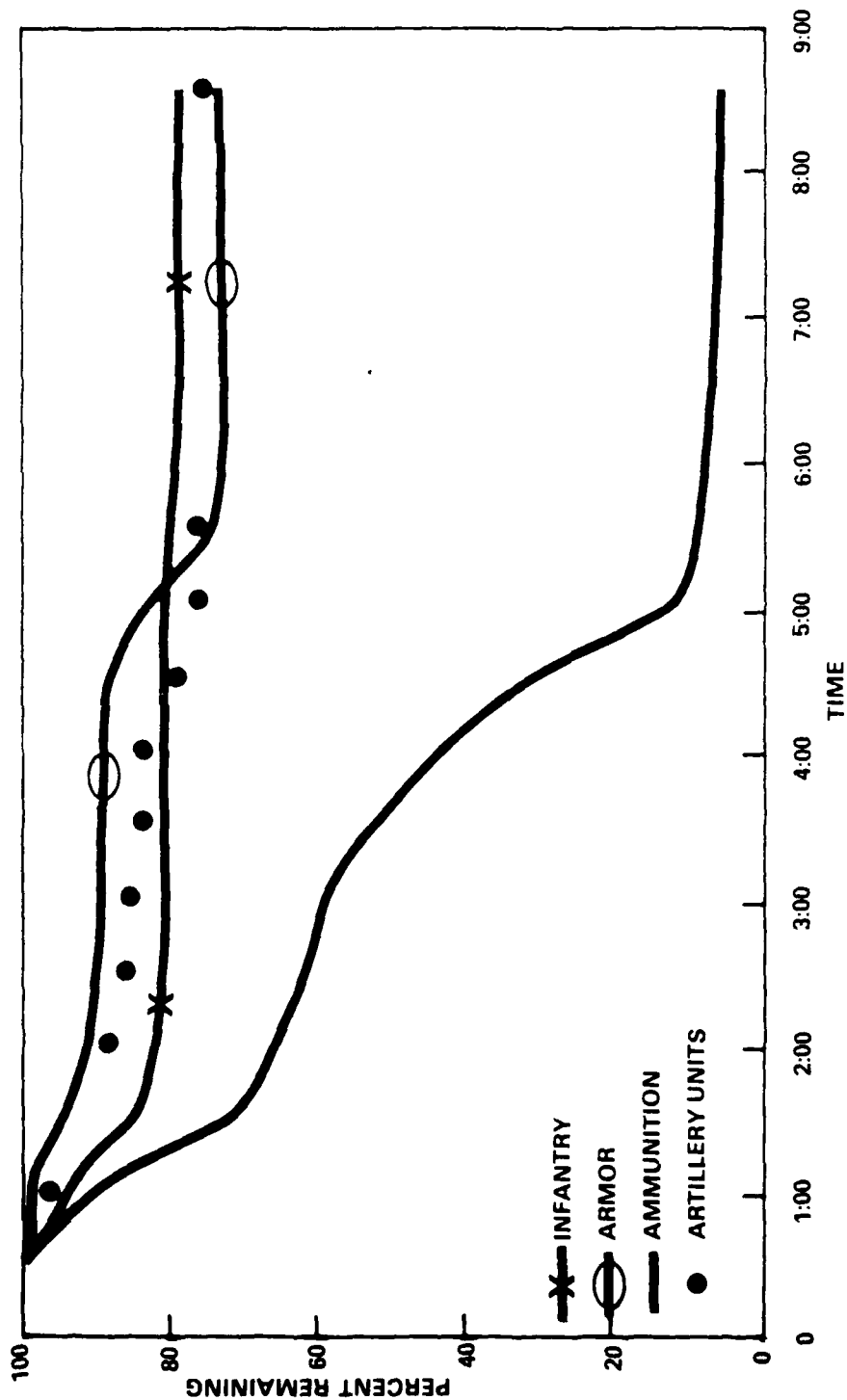
D-1

# CASE I BLUE DIVISION RESOURCES



D-2

# CASE II BLUE DIVISION RESOURCES

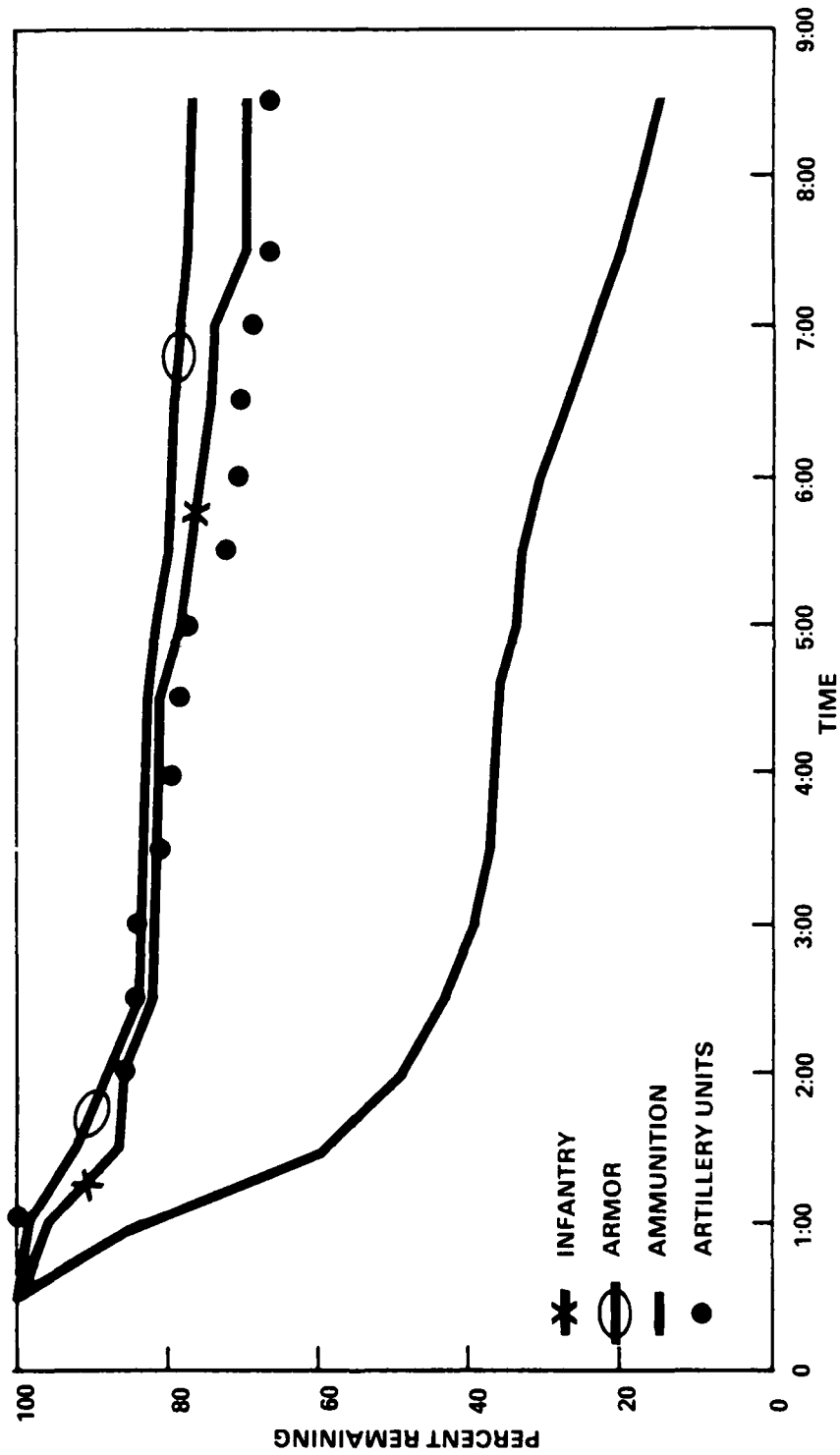




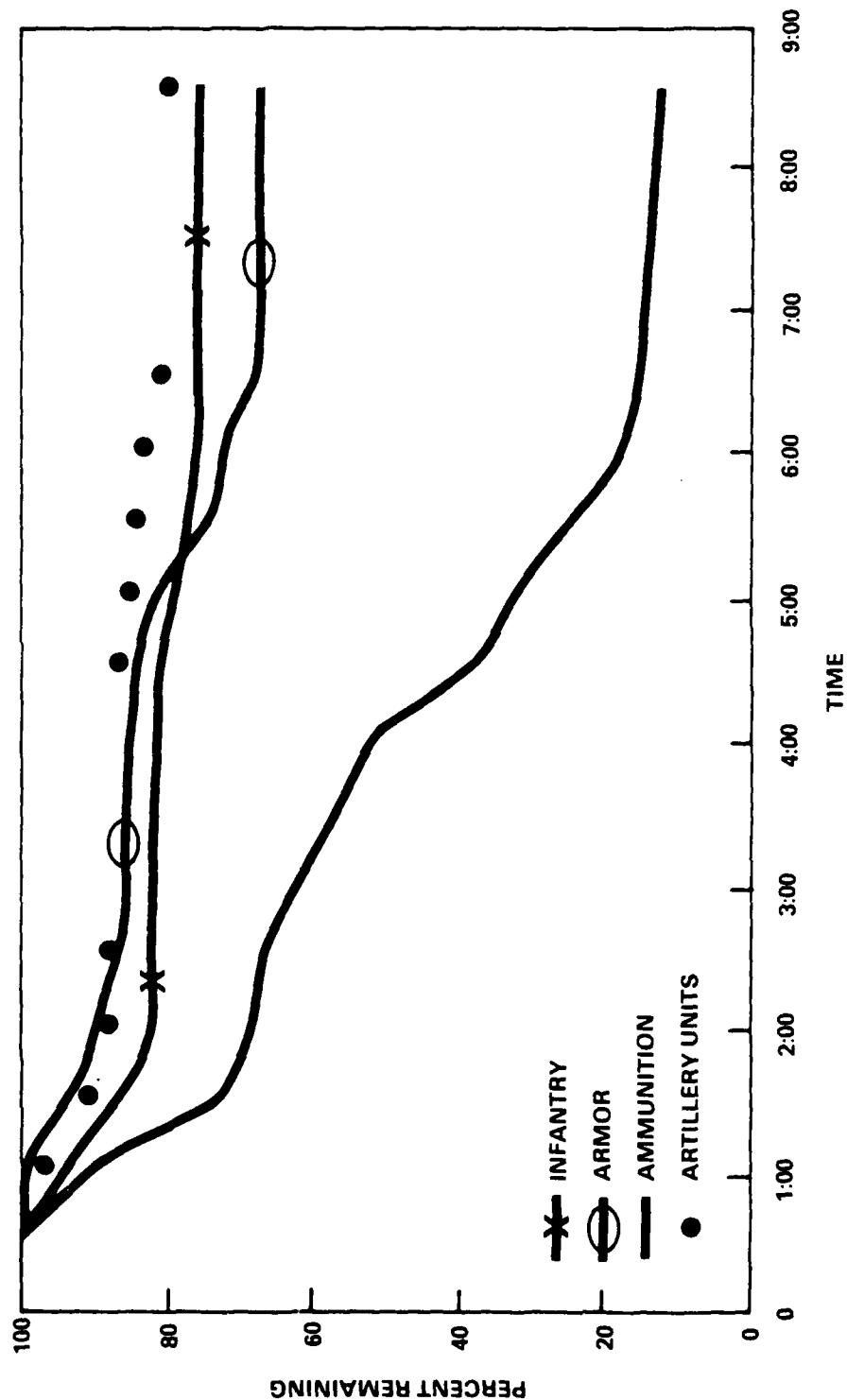
D-3

# CASE III

## BLUE DIVISION RESOURCES

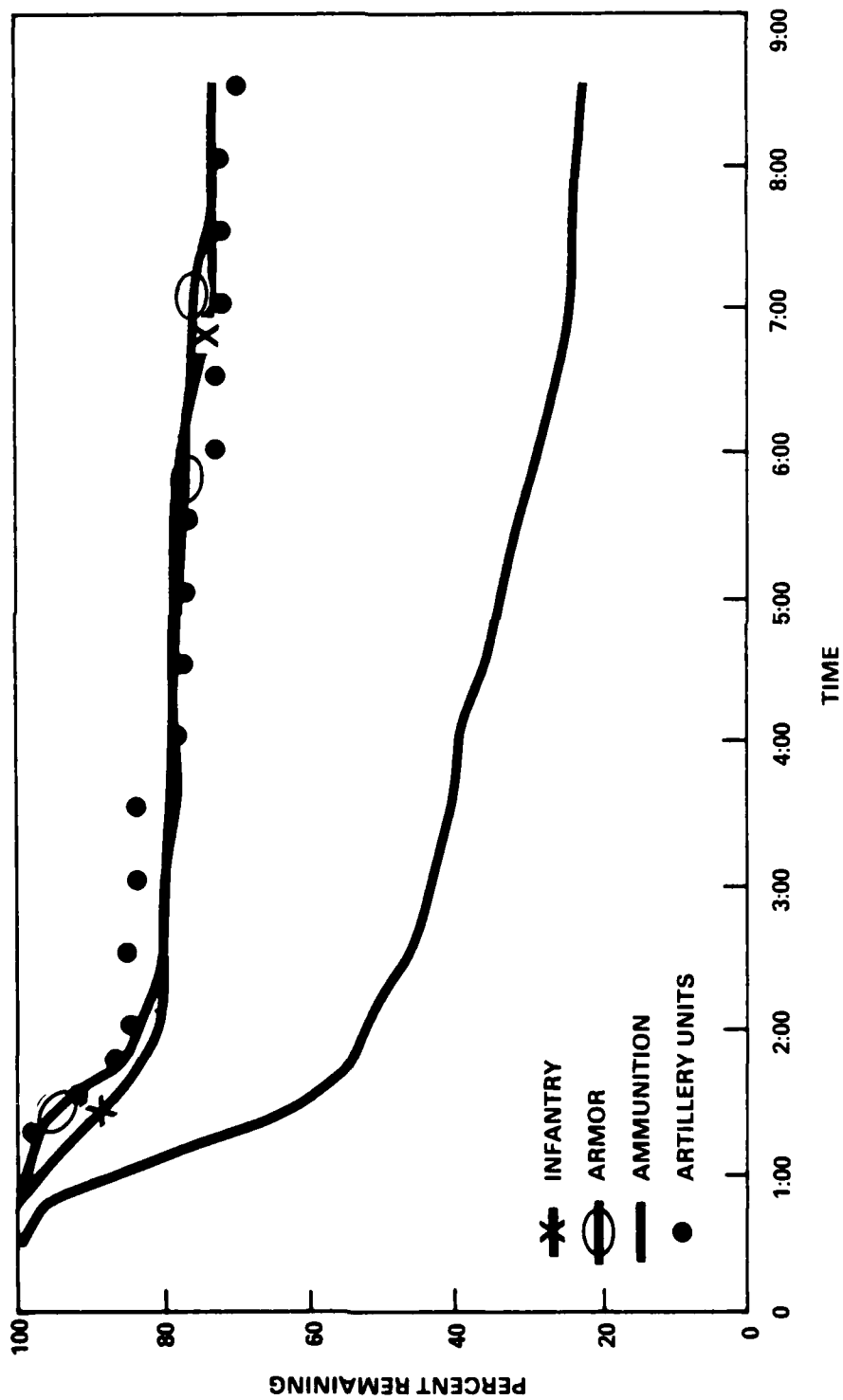


D-4  
**CASE IV**  
**BLUE DIVISION RESOURCES**



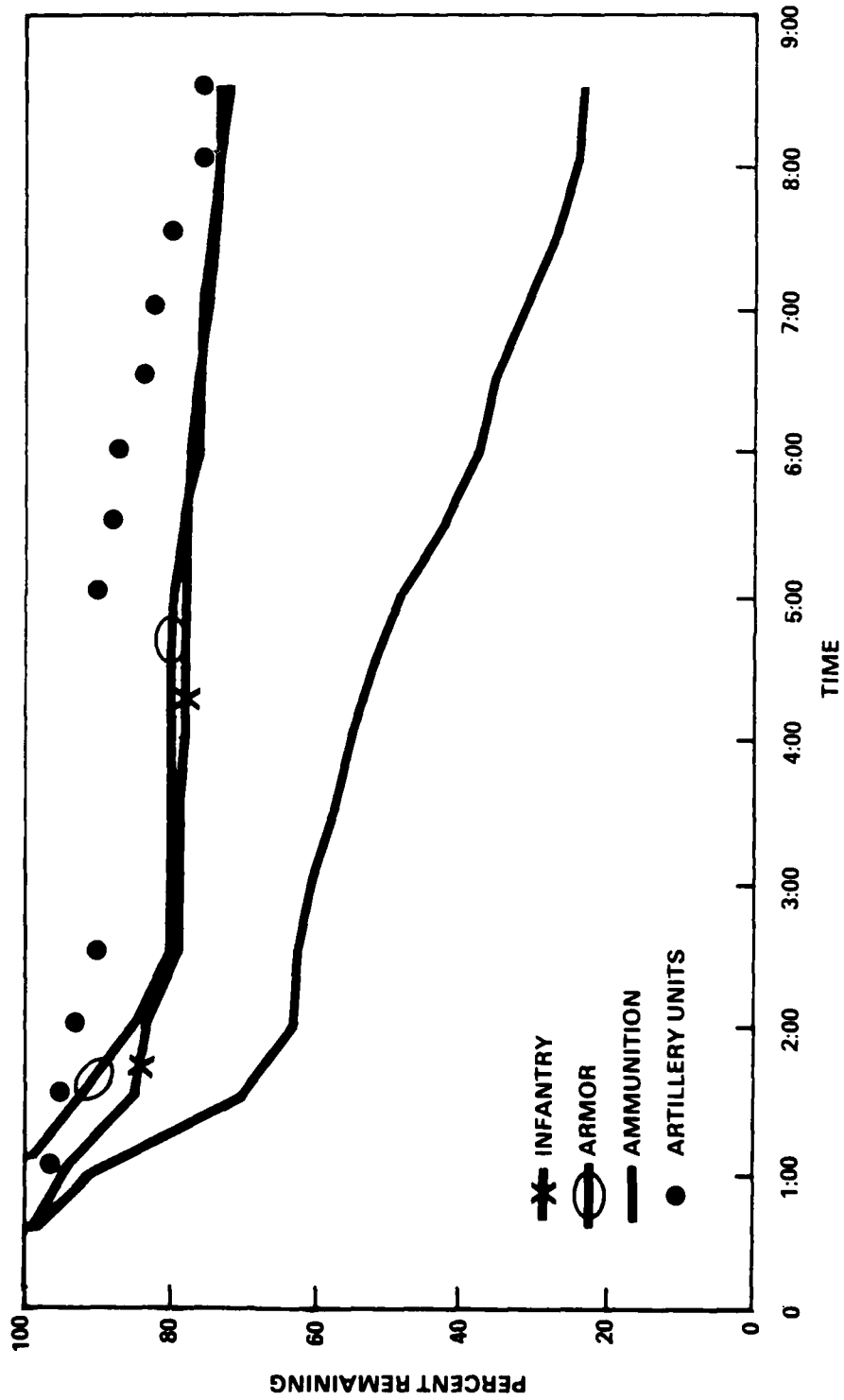
D-5

## CASE III-FP BLUE DIVISION RESOURCES



D-6

## CASE IV-FP BLUE DIVISION RESOURCES



D-7

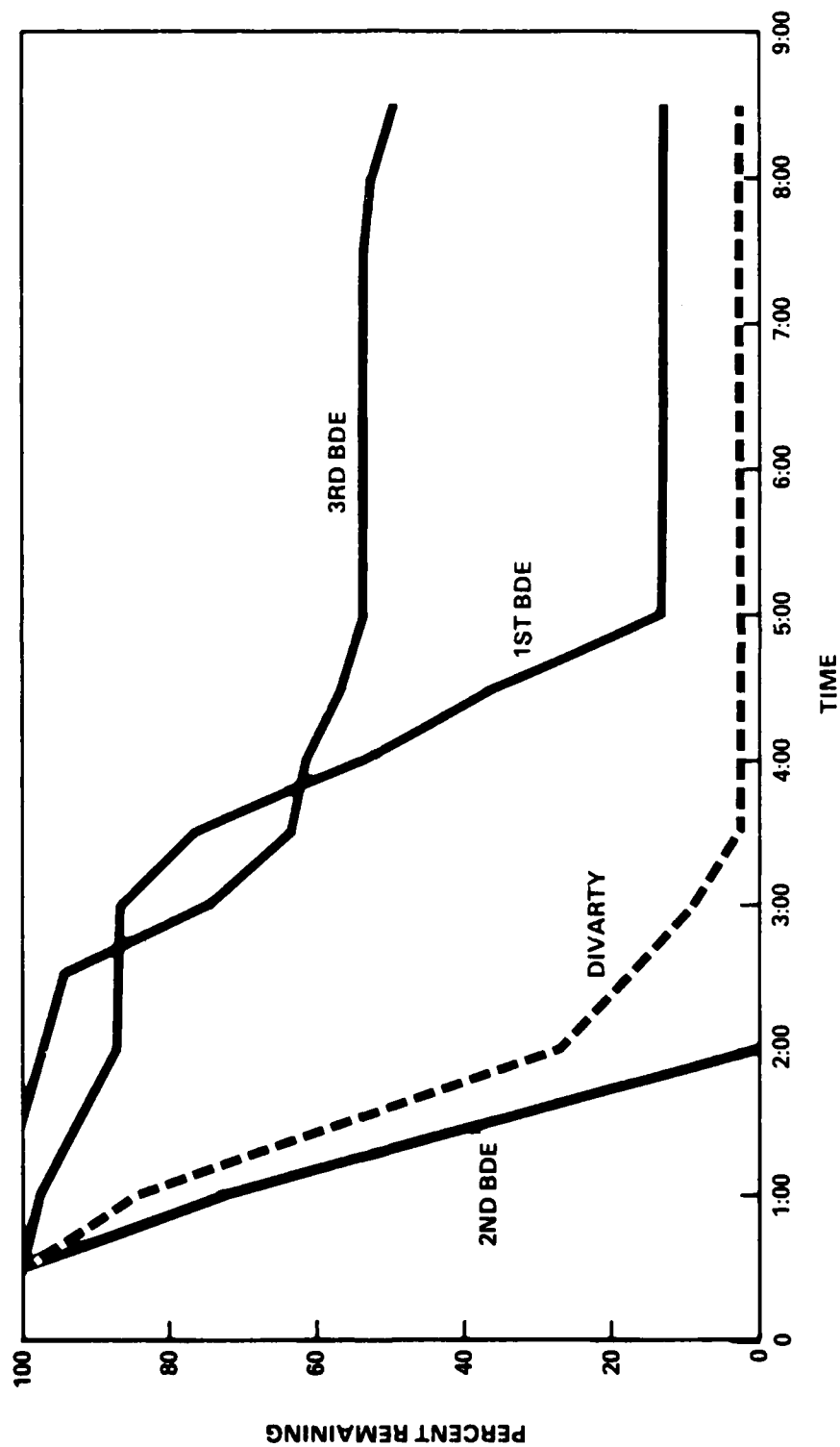


APPENDIX E  
BLUE AMMUNITION DRAWDOWN BY BRIGADE

Due to the nature of the Red attack on a very narrow frontage, Blue units engaging in combat and the attendant ammunition expenditure is highly non-uniform over Blue Division assets. The six graphs in this appendix show that effect clearly as well as the expenditure of Blue Division artillery rounds.

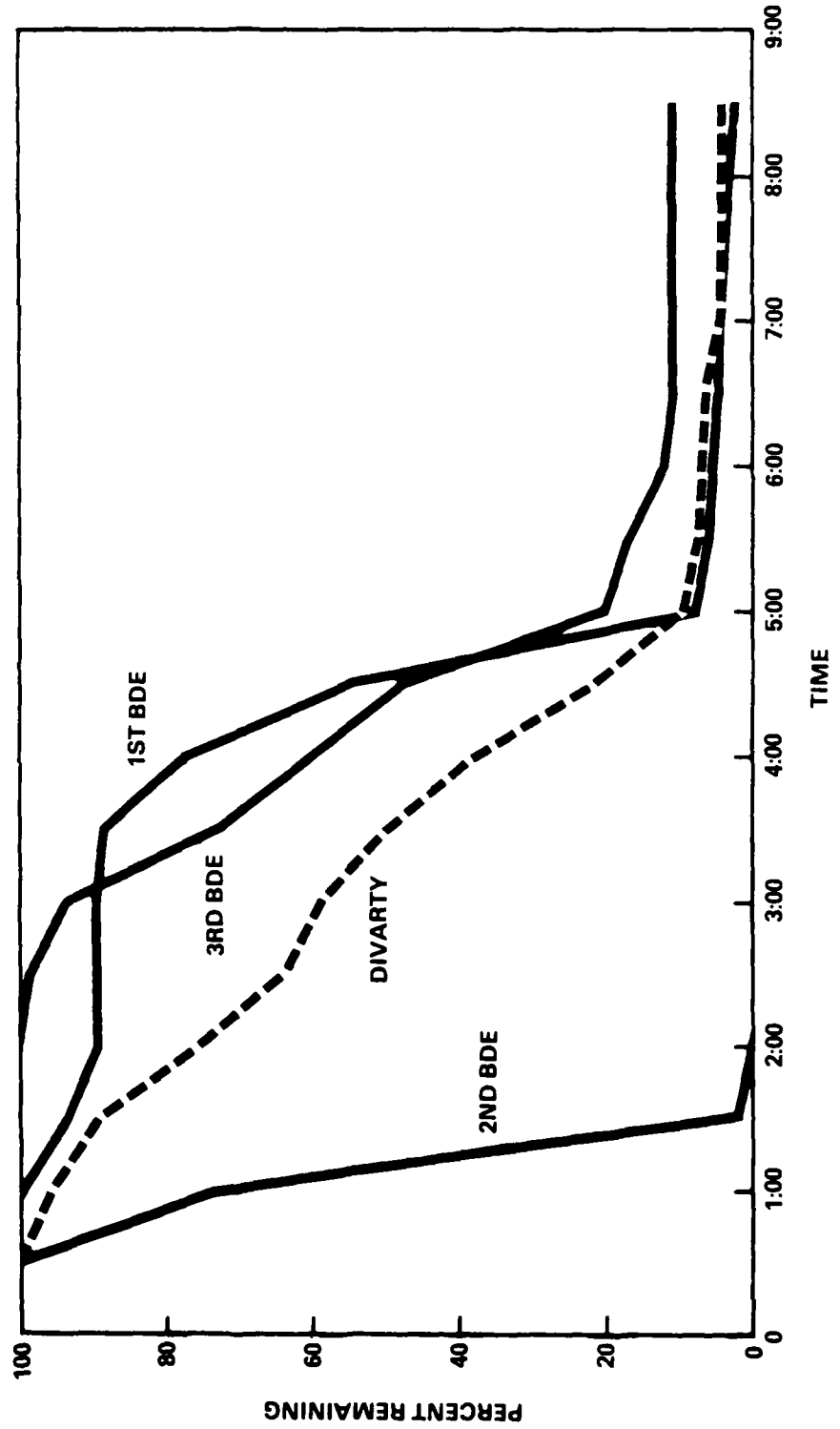
E-1

# CASE I BLUE AMMUNITION



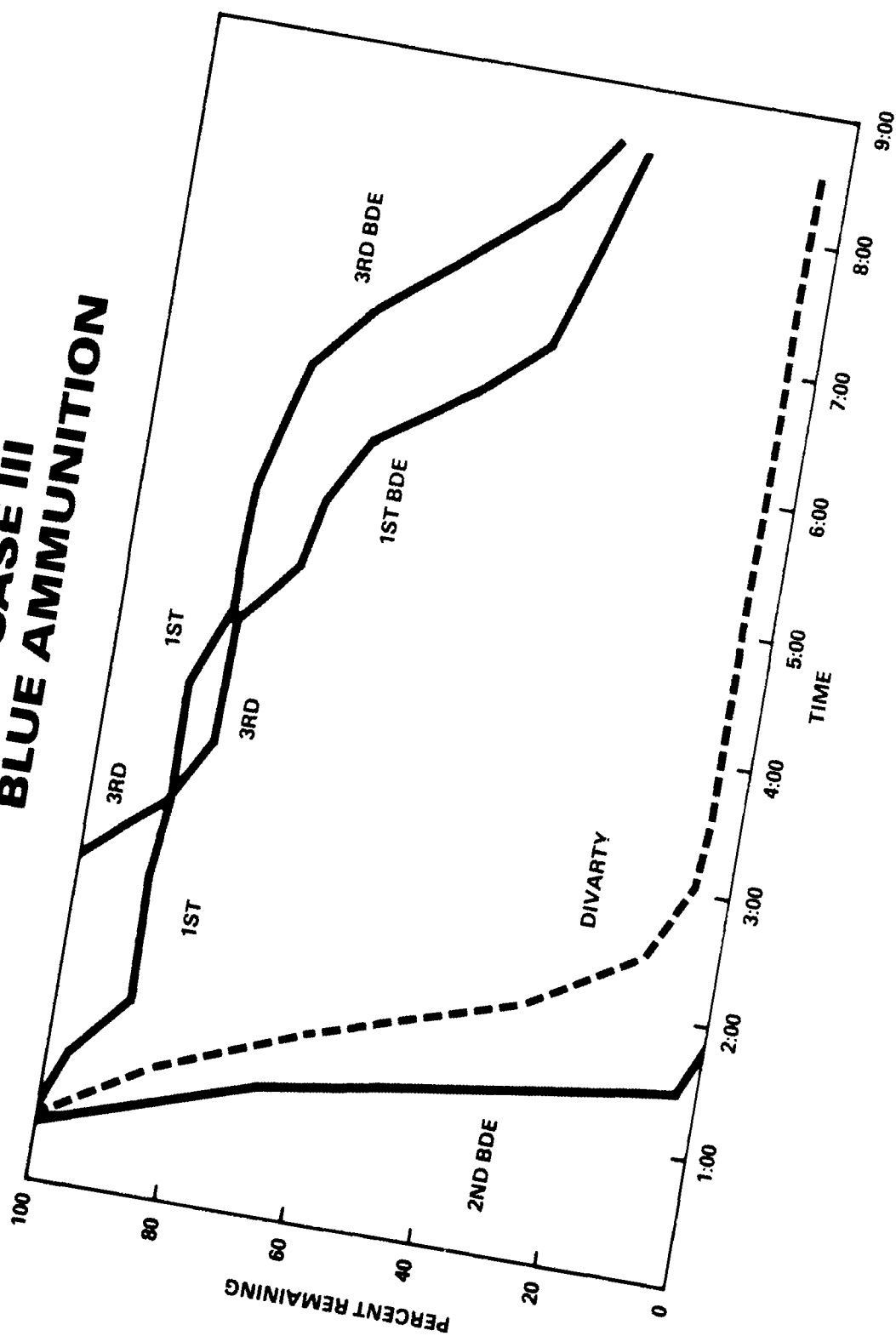
E-2

# CASE II BLUE AMMUNITION

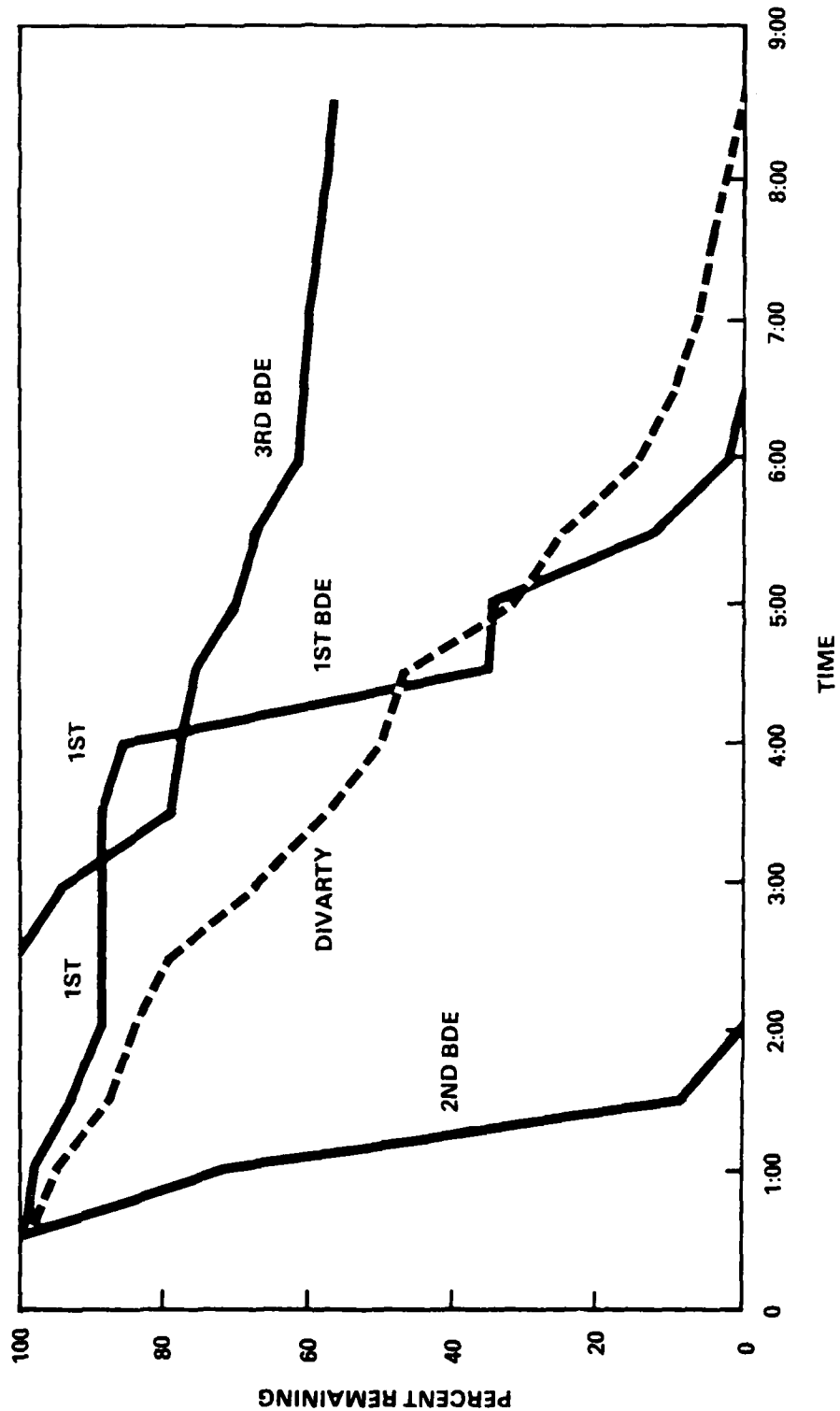




# E-3 **CASE III BLUE AMMUNITION**

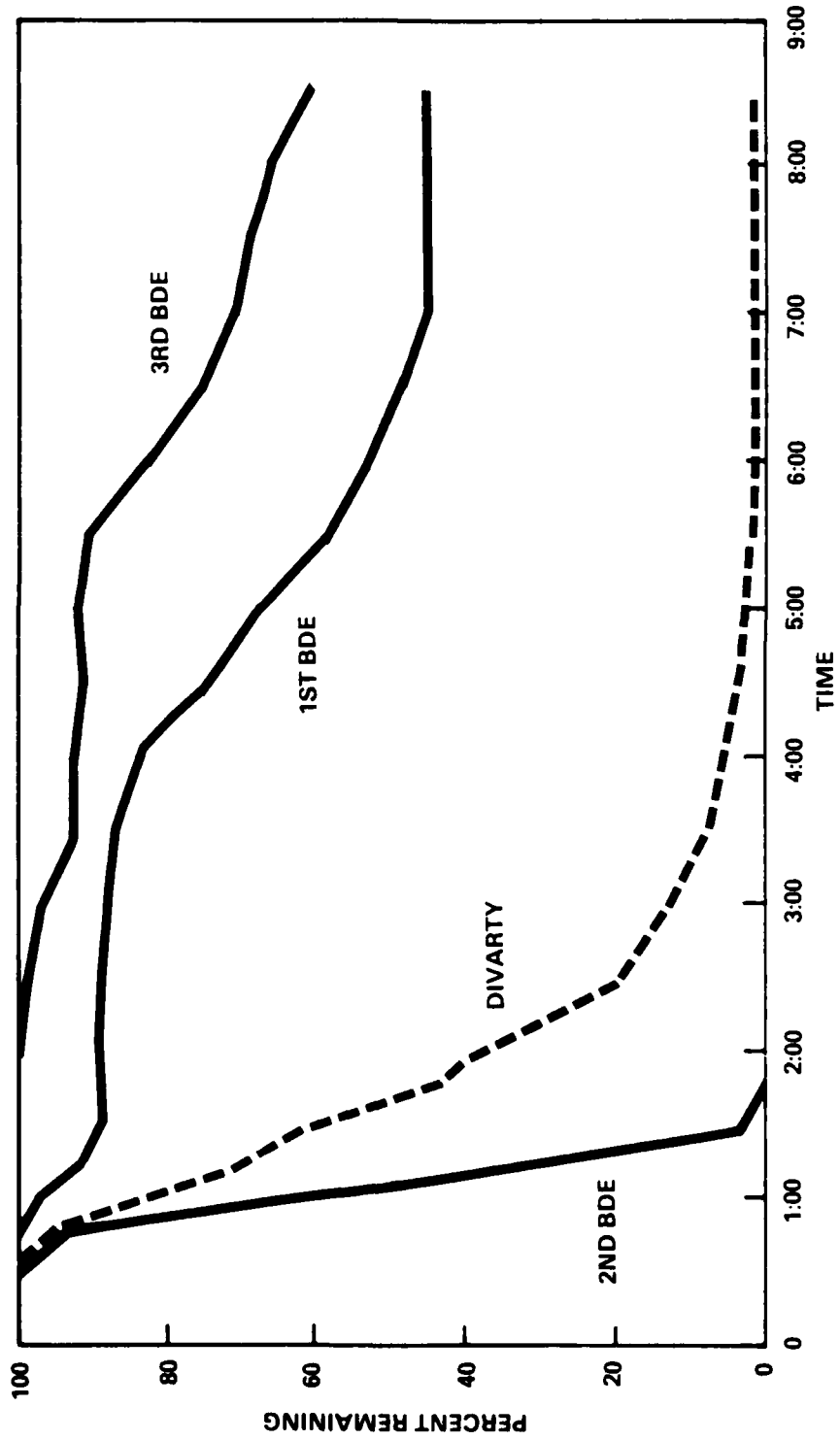


E-4  
**CASE IV**  
**BLUE AMMUNITION**

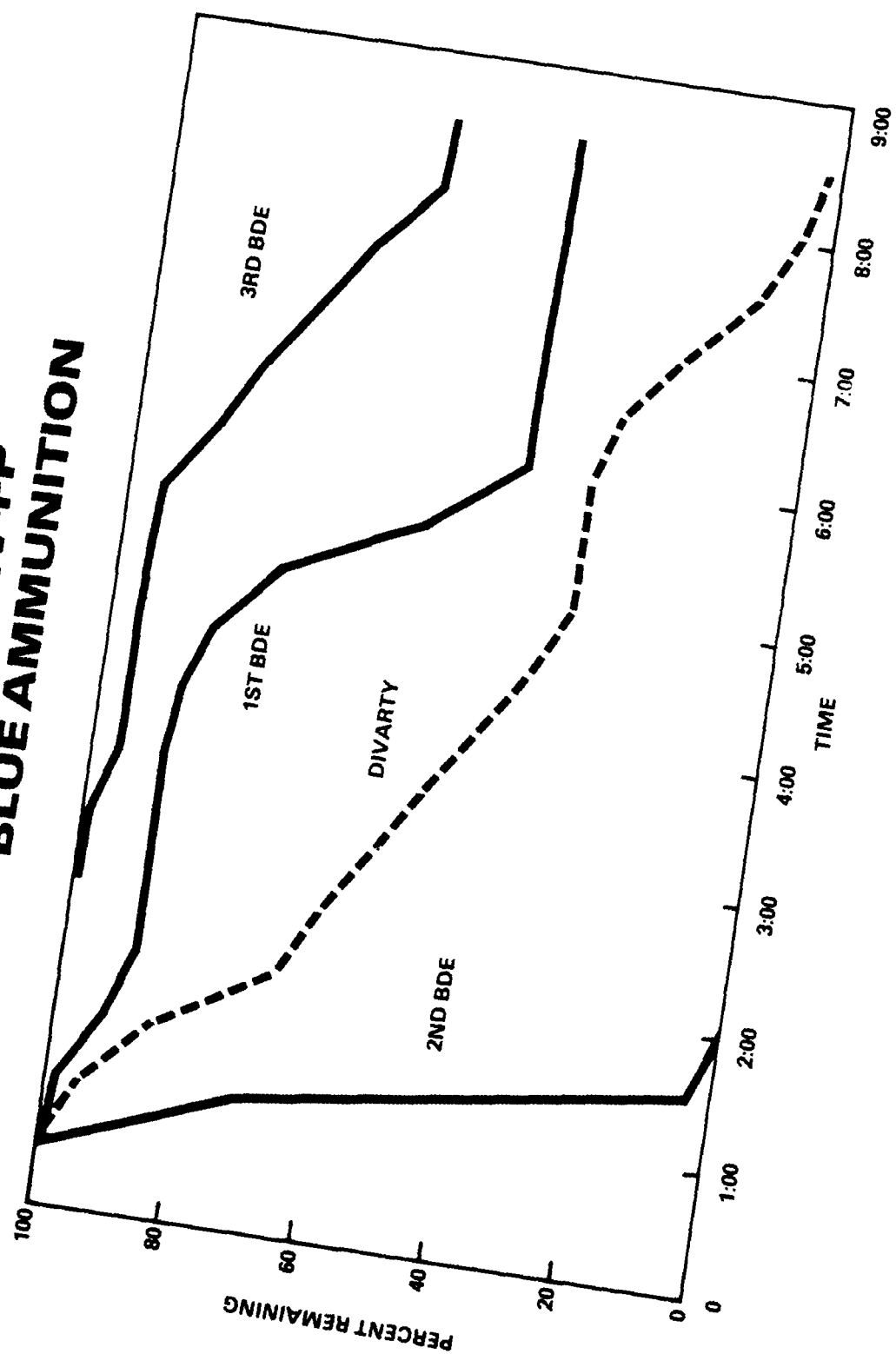


E-5

# CASE III-FP BLUE AMMUNITION



E-6  
**CASE IV-FP  
BLUE AMMUNITION**



## APPENDIX F

### CASE I TACTICAL POSITION MAPS

One of the game history post-processing capabilities developed for the TRACE model was the automatic generation of unit position maps on standard computer printer paper. This feature was used to generate tactical unit position maps at one-half hour intervals for each of the six cases examined. The 18 maps for Case I are presented in this appendix while those for Cases II through IV-FP appear in Appendices G through K respectively. Explanatory information regarding these maps is given in the subsequent paragraphs of this appendix and is applicable to all six Appendices F through K.

The TCOR based family of models employs a hexagonal grid coordinate system. Locations in a hexagonally-tiled plane are specified by the numerical identifier of the hexagon within which the point of interest lies. In the six TRACE cases, the plane (battlefield) is perfectly tiled with 1.35 km diameter hexagons (center-to-center distance between adjacent hexagons is also 1.35 km). The greatest unit location accuracy obtainable, therefore, is to specify that it is within one of these hexagons. TRACE is capable, however, of tiling the plane with 73 meter diameter hexagons at the finest grain and these are referred to as level zero hexes. Any given hexagon is surrounded by six others like itself and these seven taken together constitute a level-of-aggregation. The model allows up to twelve levels of aggregation and we are using the third level as our basic hexagonal tiling of the plane. A level three hex contains roughly the area that would normally be occupied by a Company size unit while level four a battalion and level five a brigade.

The post-processor will plot unit positions using any hex level and hexagonal grids at any other level as long as the lowest level used in the game is not exceeded (not less or smaller than the game level). The unit position maps that we will see in these appendices were plotted at level three accuracy (the greatest available) and have a level five hexagonal grid superimposed on them. The level five hexagonal grid system is

shown in Figure F-1 along with a legend tht identifies the actual hexagonal address of each brigade size hexagon. Figure F-2 presents a table that allows one to determine the latitude and longitude coordinates of the center of each hexagon in the grid.

Letters of the alphabet for the Blue side and numerals for Red are used to identify unit locations on the position maps. The particular letter or numeral used is related to the type of unit being located as shown in Figure F-3. Note also in Figure F-3 that level three units are being plotted and hence each letter/numeral represents a company/battery size unit.

If several units are clustered in a small geographic area, the plot scale selected may not allow a symbol to be plotted for all of the units at that location. The units that are plotted is based simply on "first-encountered first-plotted" as they occur on the game history file. Dead units are not plotted at all but neutralized units are. The information given in Figure F-1, F-2, and F-3 are always the first three pages of output for any post-game plotting request.

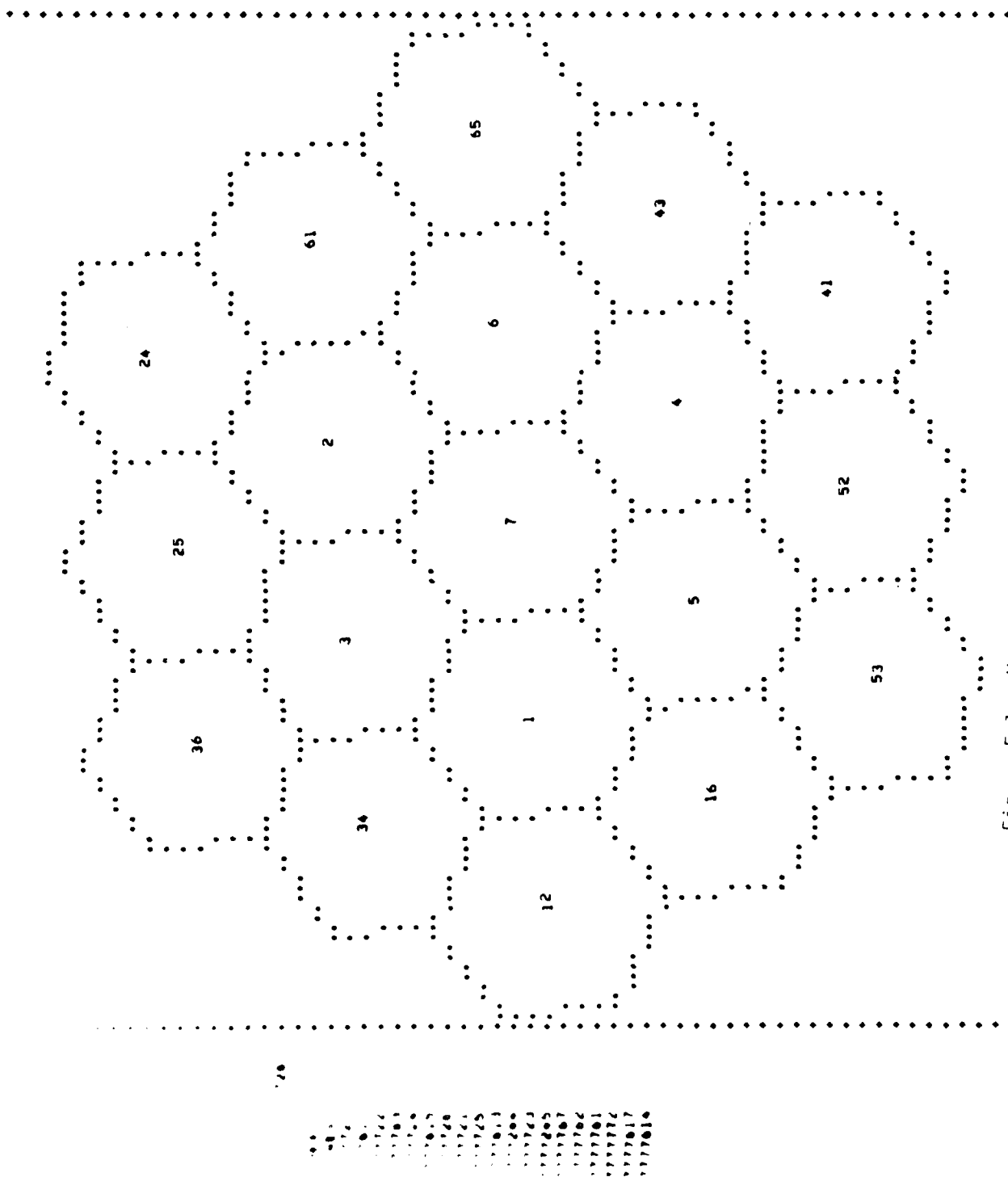


TABLE RELATING THE LATITUDE AND LONGITUDE FOR  
A GIVEN HEX ADDRESS FOR BRIGADE SIZE HEXES

| LEGEND<br>NUMBER | HEX<br>ADDRESS | (DEG)<br>LATITUDE | (DEG)<br>LONGITUDE | LEVEL |
|------------------|----------------|-------------------|--------------------|-------|
| 2                | 7777611        | 50.810            | 9.723              | 5     |
| 3                | 7777722        | 50.802            | 9.589              | 5     |
| 4                | 7777763        | 50.663            | 9.744              | 5     |
| 5                | 7777724        | 50.655            | 9.611              | 5     |
| 6                | 7777615        | 50.741            | 9.800              | 5     |
| 7                | 7777726        | 50.733            | 9.667              | 5     |
| 12               | 7777721        | 50.716            | 9.400              | 5     |
| 16               | 7777725        | 50.647            | 9.478              | 5     |
| 24               | 7777613        | 50.888            | 9.779              | 5     |
| 25               | 7777244        | 50.880            | 9.645              | 5     |
| 34               | 7777723        | 50.794            | 9.455              | 5     |
| 36               | 7777245        | 50.872            | 9.511              | 5     |
| 41               | 7777767        | 50.594            | 9.822              | 5     |
| 43               | 7777762        | 50.671            | 9.878              | 5     |
| 52               | 7777761        | 50.586            | 9.689              | 5     |
| 53               | 7777772        | 50.577            | 9.555              | 5     |
| 61               | 7777617        | 50.819            | 9.857              | 5     |
| 65               | 7777614        | 50.749            | 9.934              | 5     |

Figure F-2. Coordinate conversion table for hex maps



THE FOLLOWING ARE SNAPSHOTS FROM  
OF EVERY 1 TIME POINTS

0 TO 36000.

3 LEVEL UNITS ARE DISPLAYED

| BLUE | SYMBOLS | UNIT | RED |
|------|---------|------|-----|
| A    | HQ      | 1    |     |
| B    | INF     | 2    |     |
| C    | ART     | 3    |     |
| D    | TNK     | 4    |     |
| E    | REC     | 5    |     |
| F    | MISC    | 6    |     |

Figure F-3. Position map plotting symbology

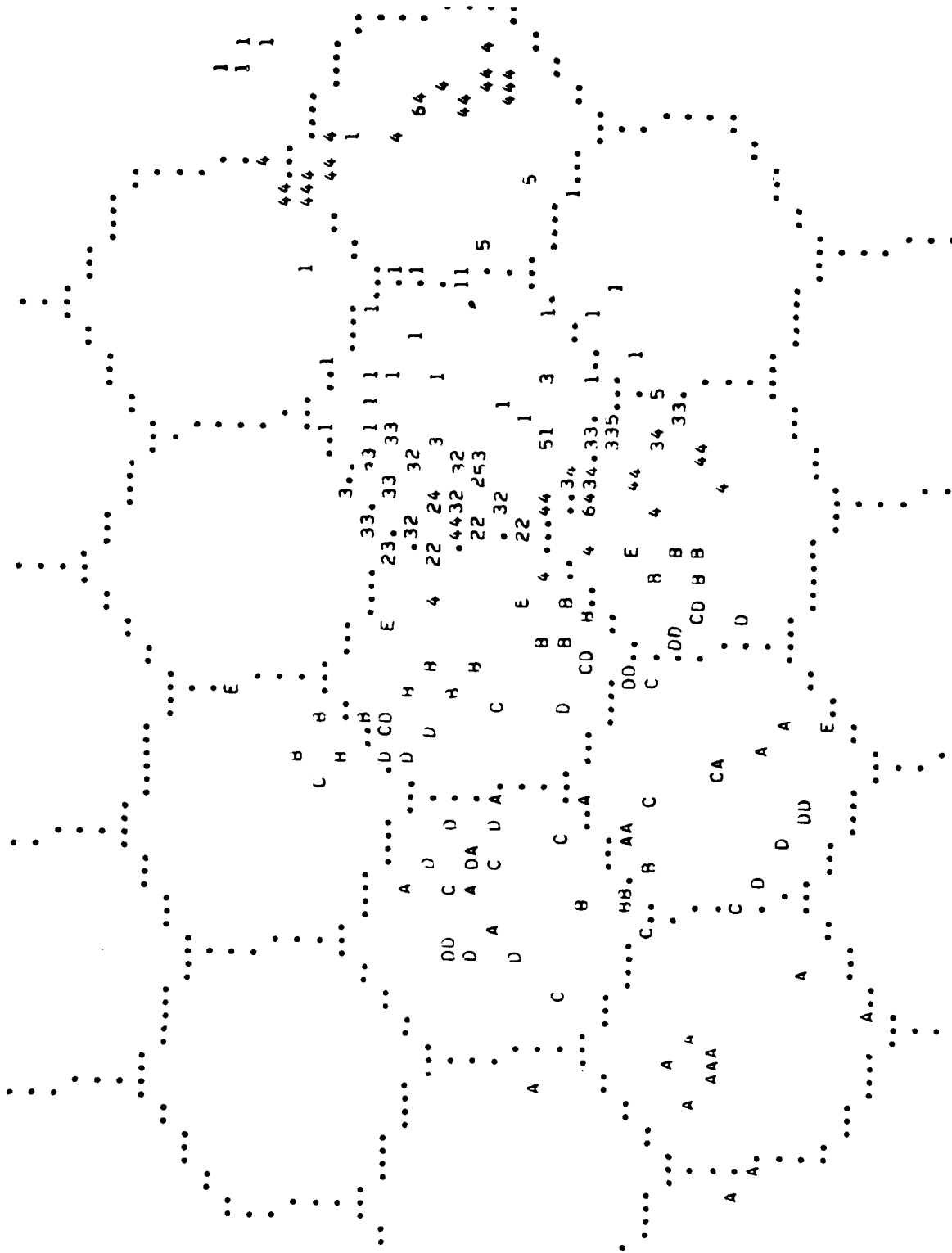


Figure F-4. Case I unit positions at 00:00 hours.

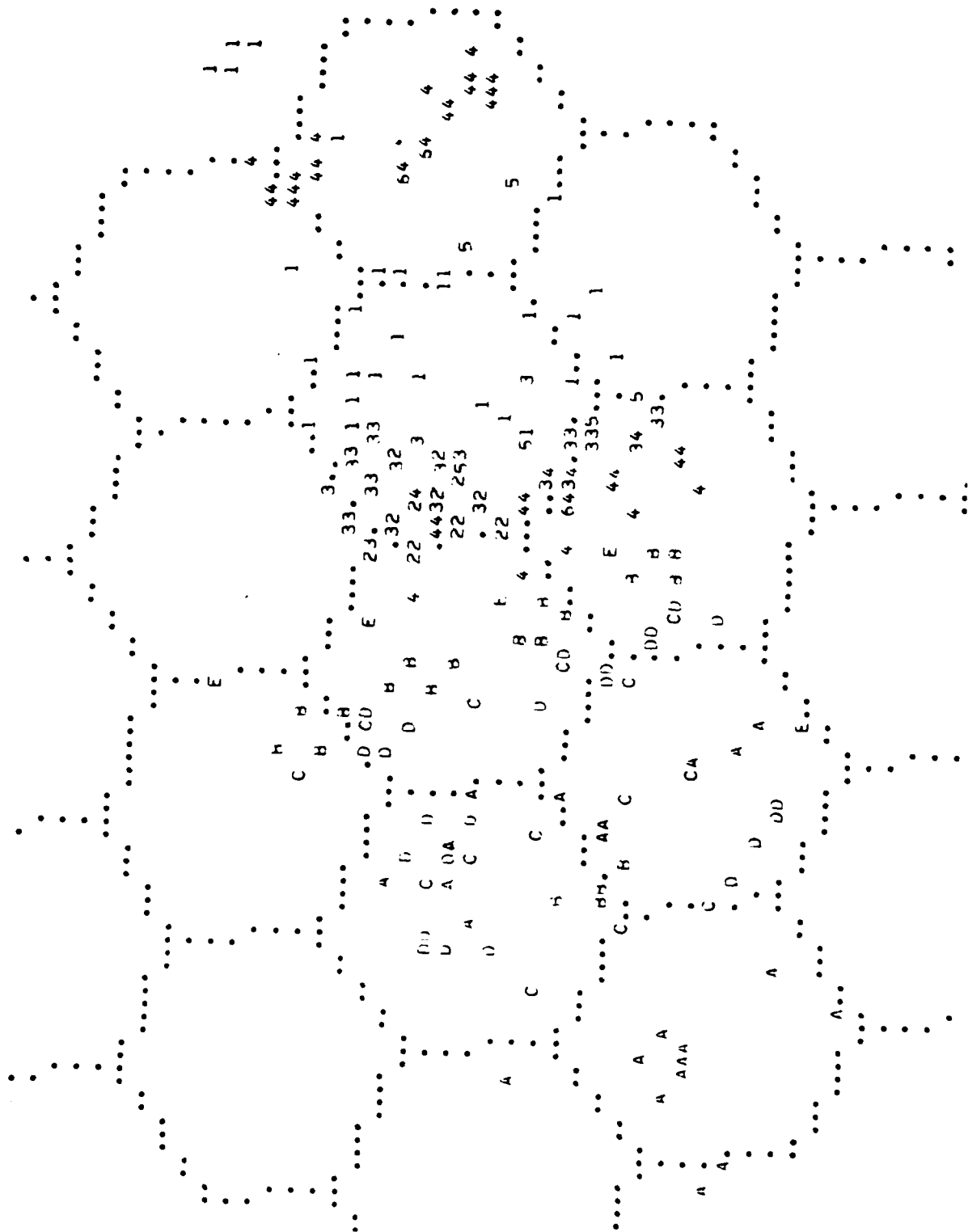


Figure F-5, Case I unit positions at 00:30 hours.

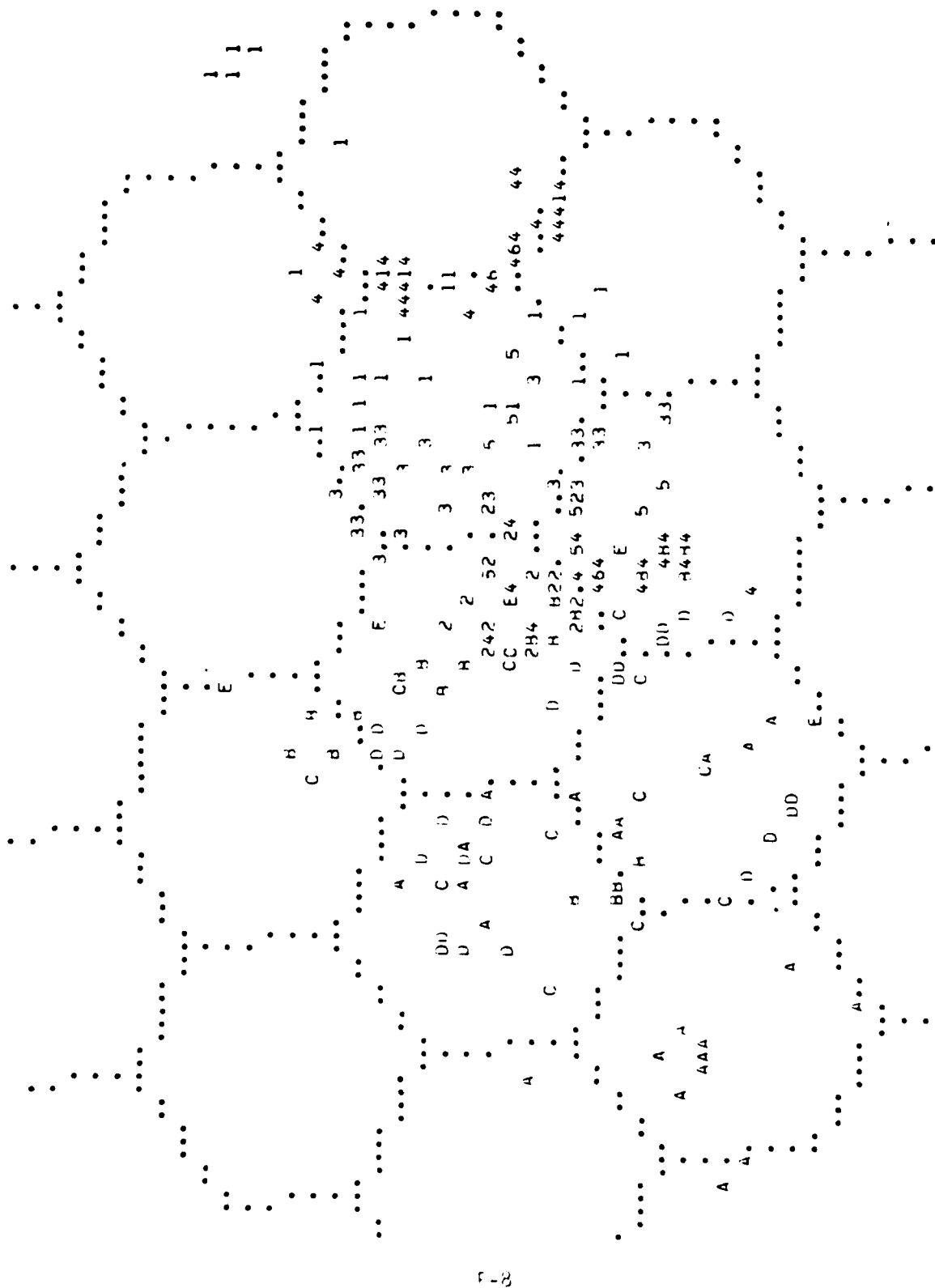


Figure F-6. Case I unit positions at 01:00 hours.

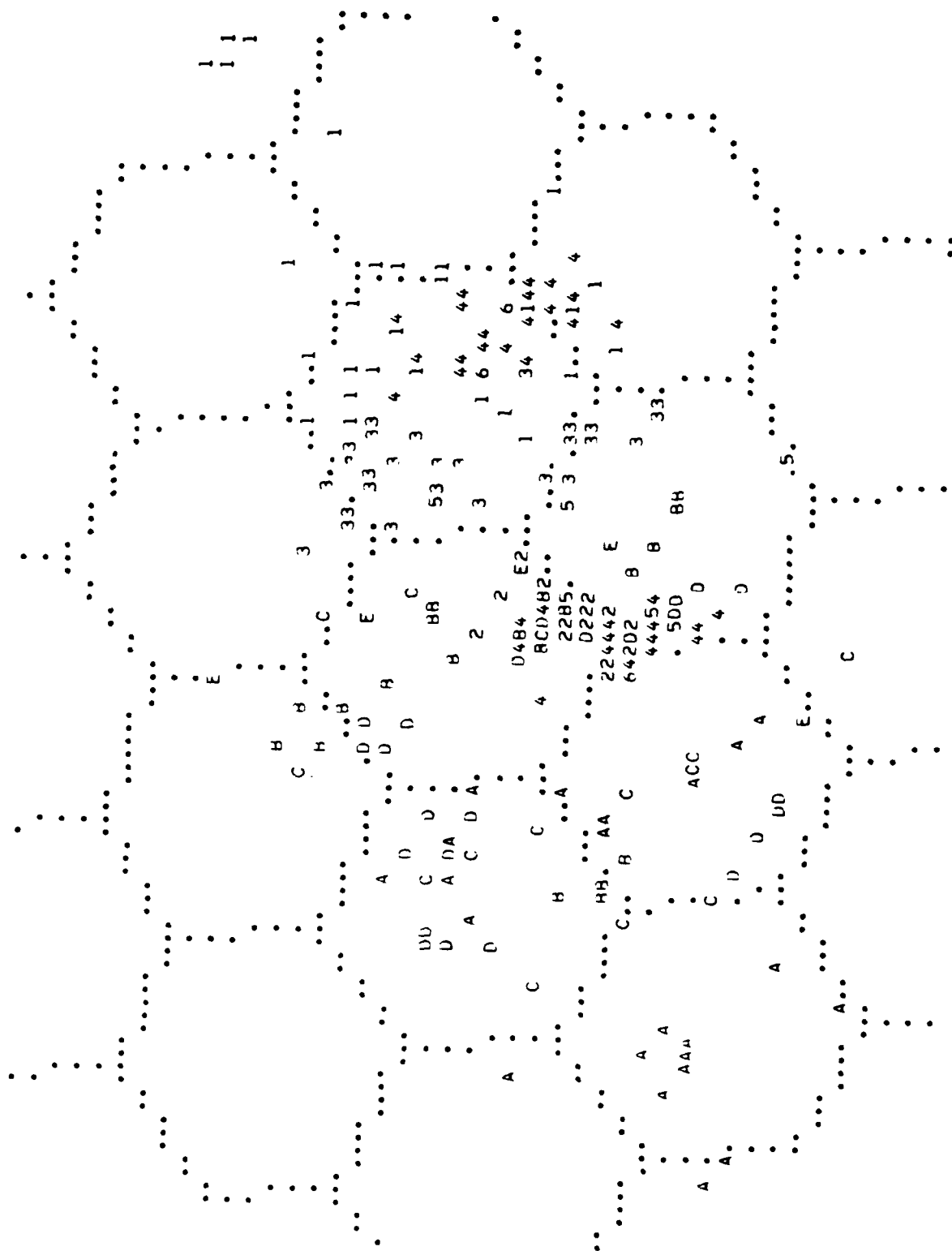


Figure F-7. Case I unit positions at 01:30 hours.

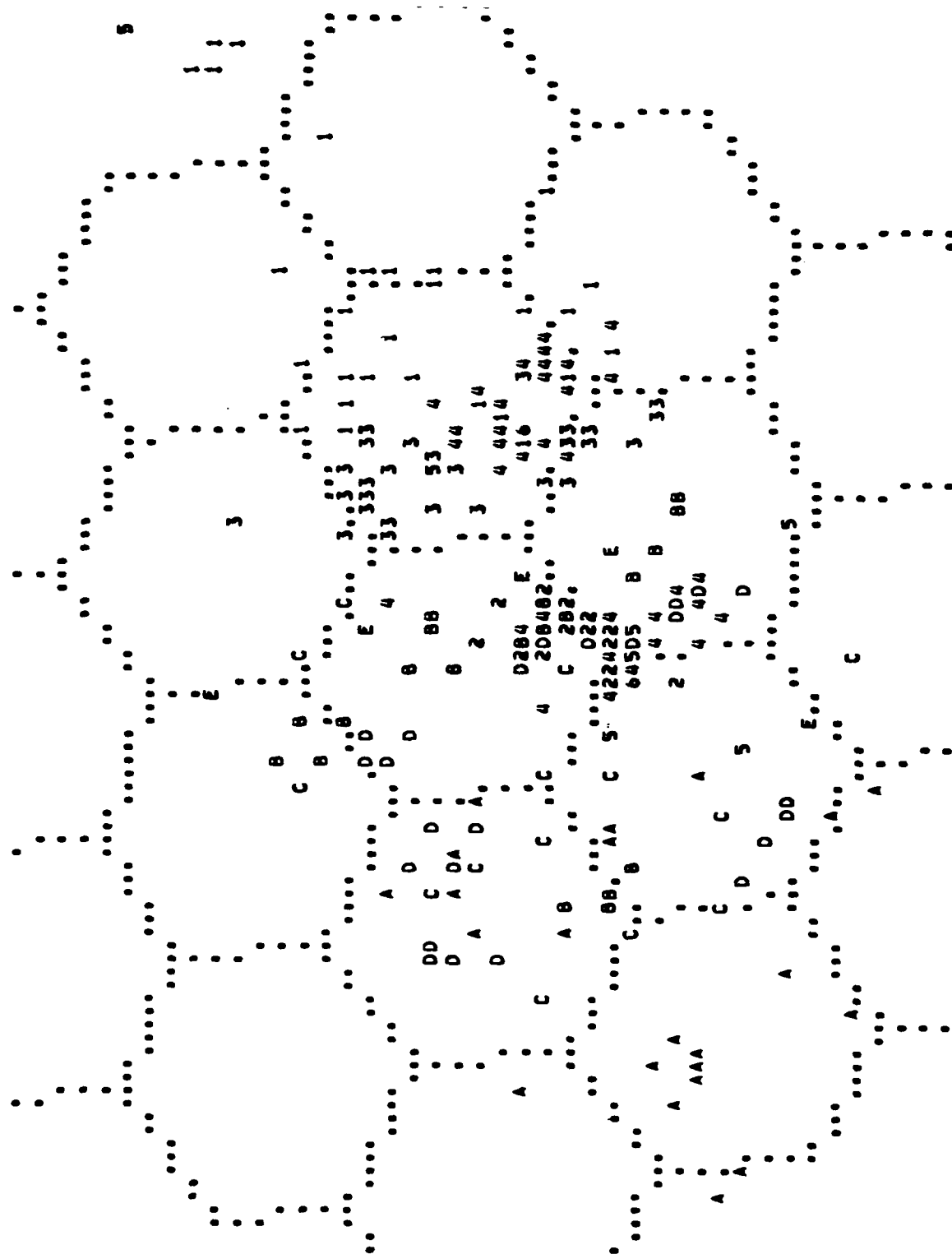


Figure F-8. Case I unit positions at 02:00 hours.

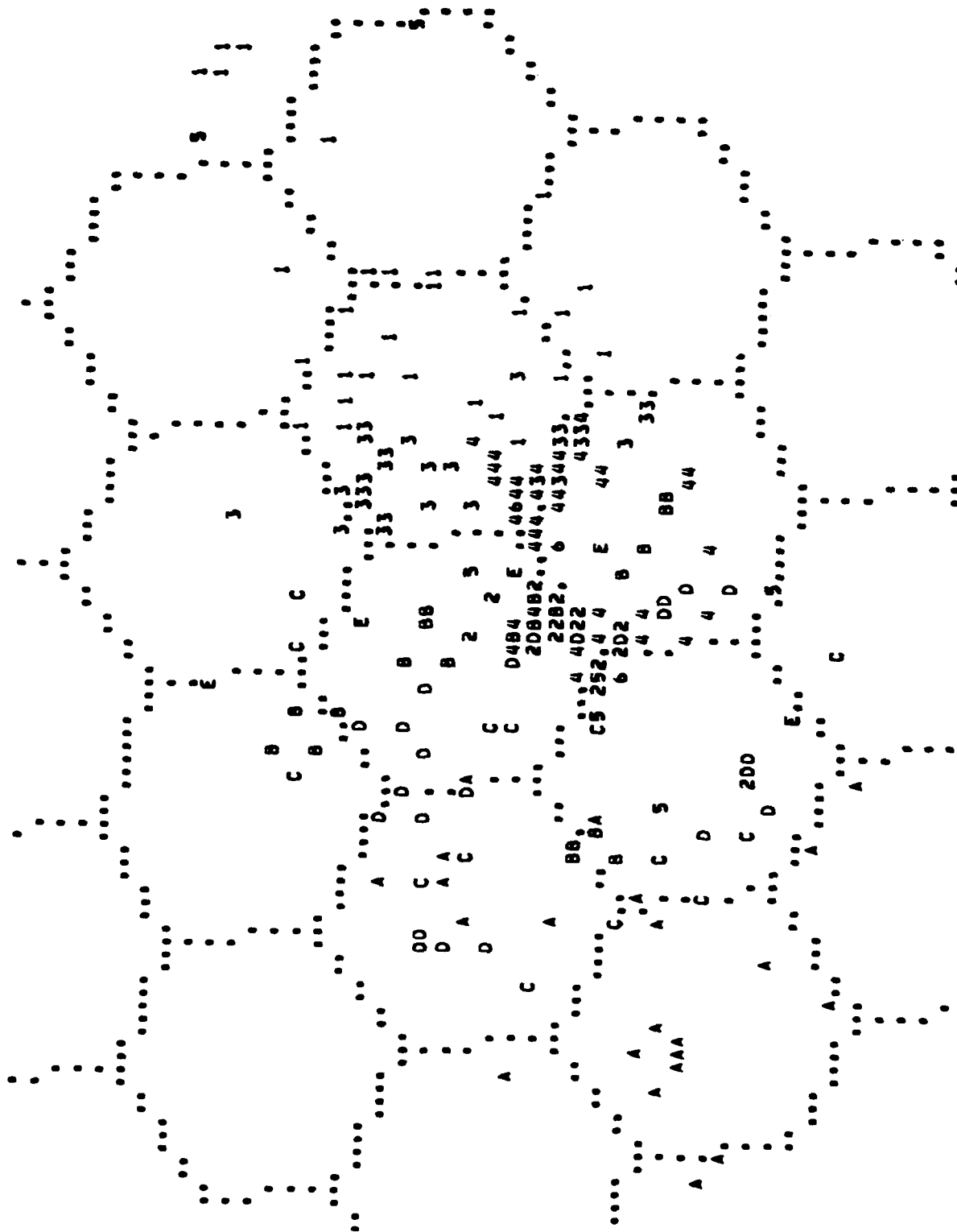


Figure F-9. Case I unit positions at 02:30 hours.

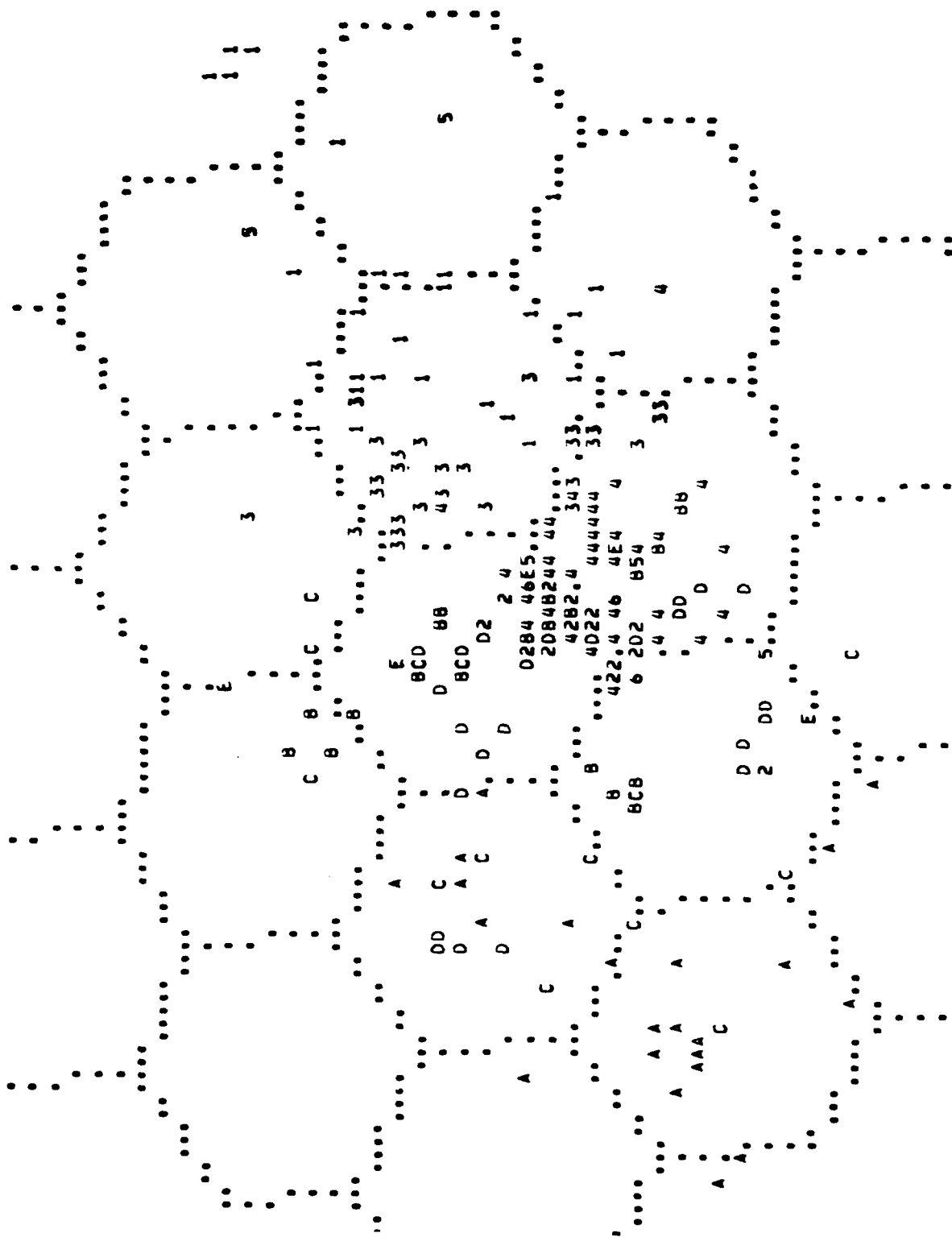


Figure F-10. Case I unit positions at 03:00 hours.





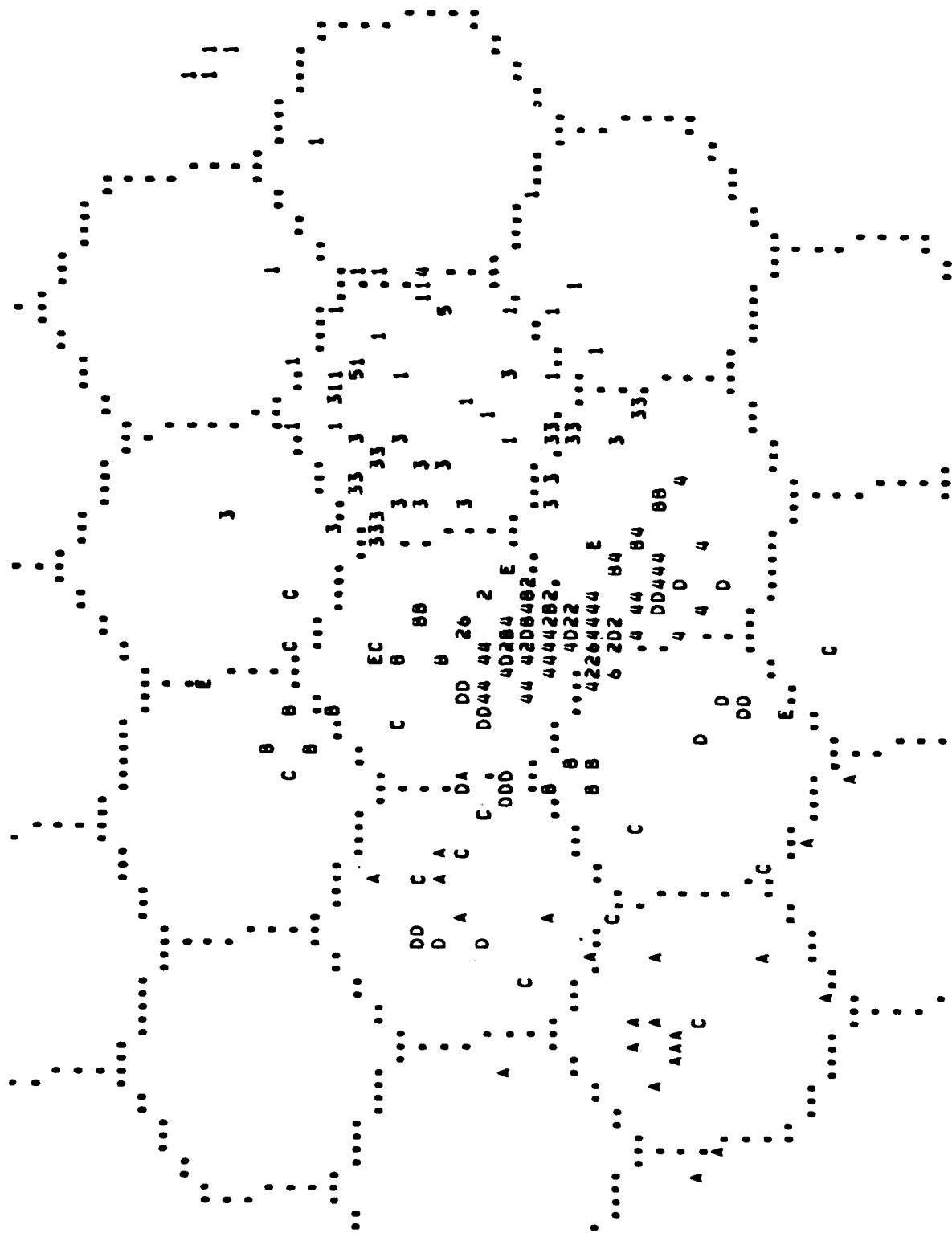
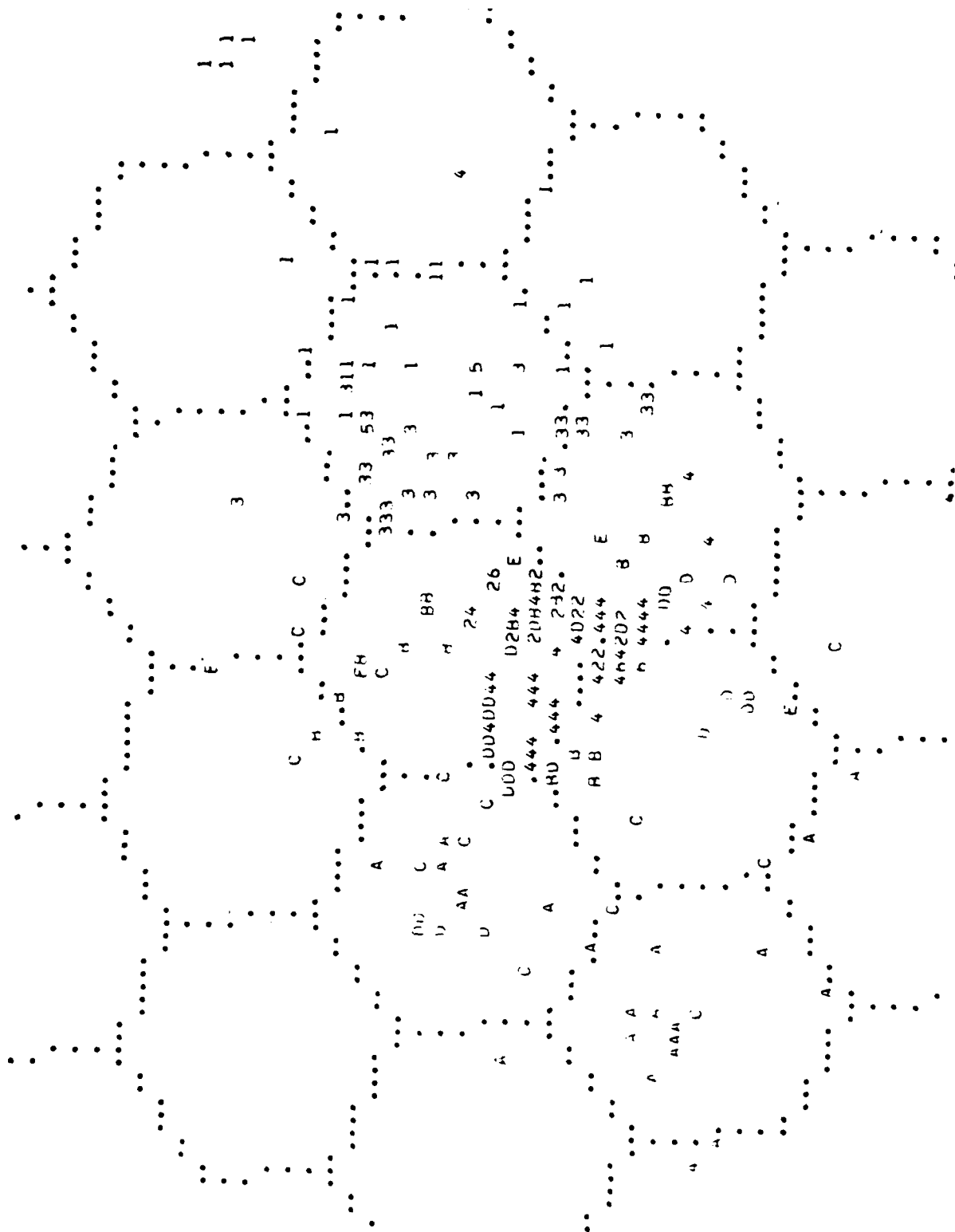


Figure F-12. Case I unit positions at 04:00 hours.



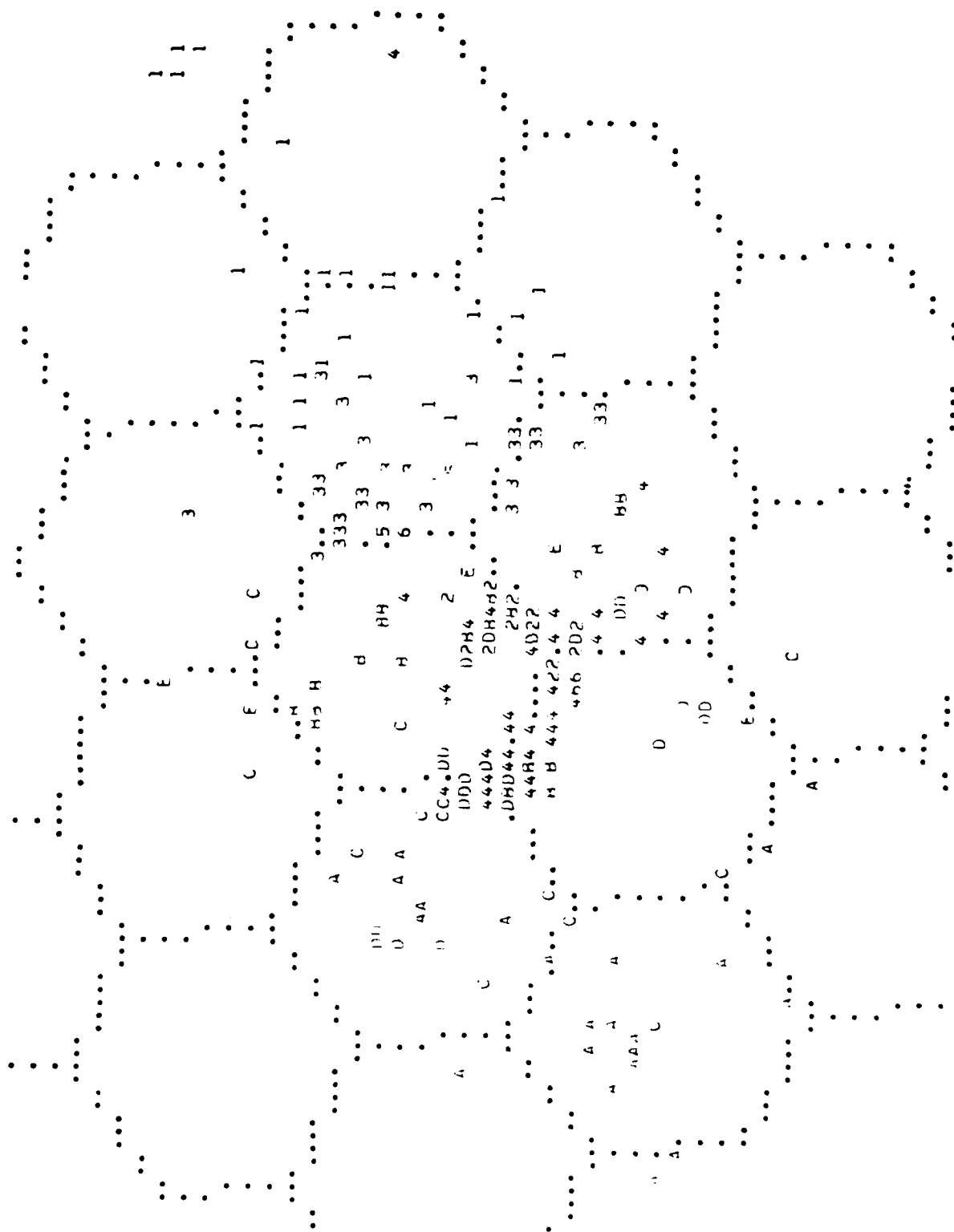


Figure F-14. Case I unit positions at 05:00 hours.

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BOM/W-80-055-TR DNA-5238F

F/6 17/2

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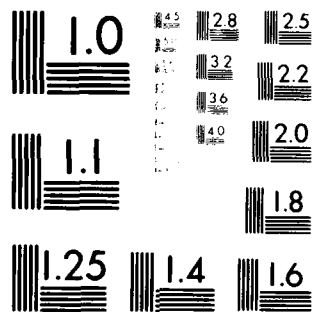
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ML

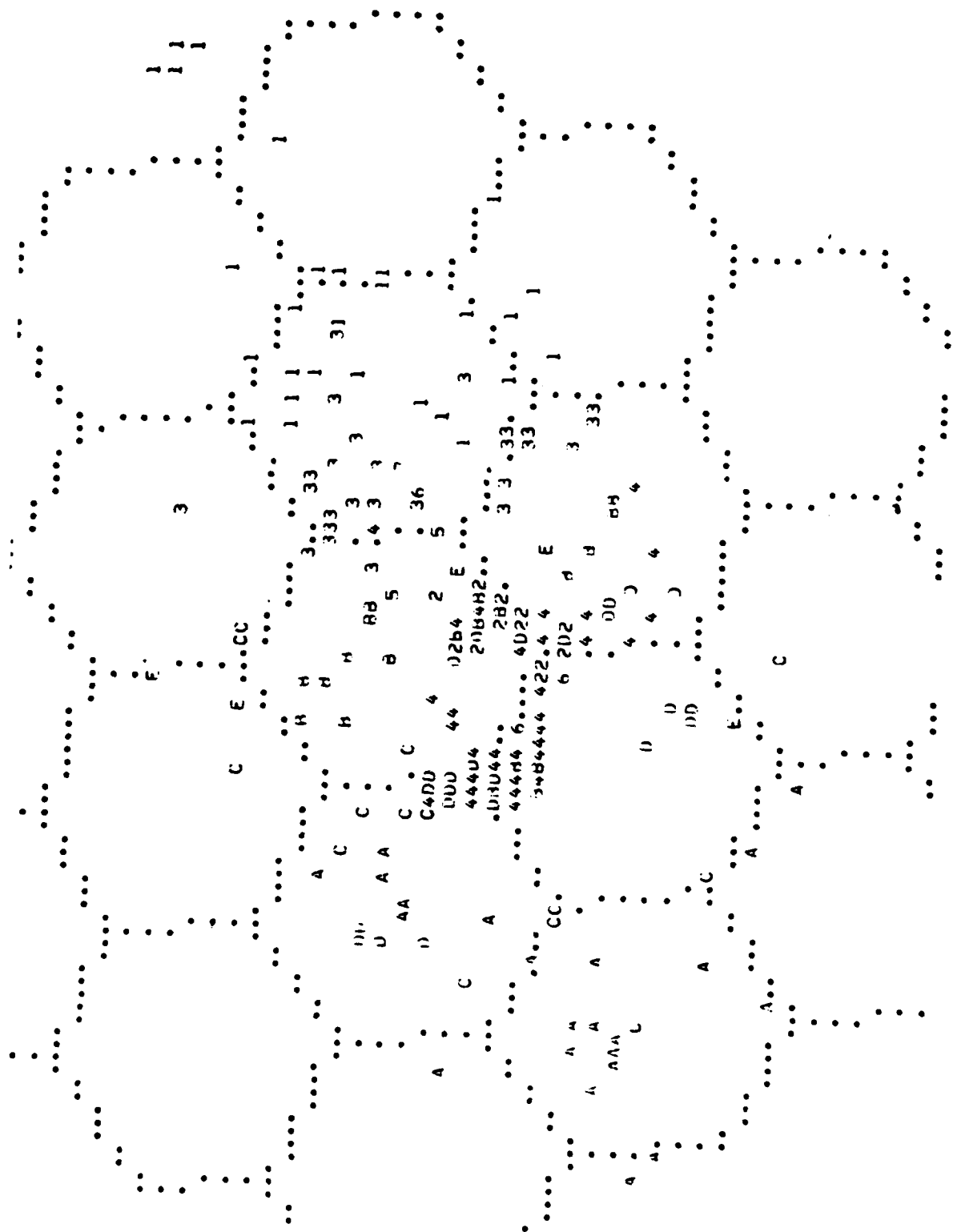
3 of 4

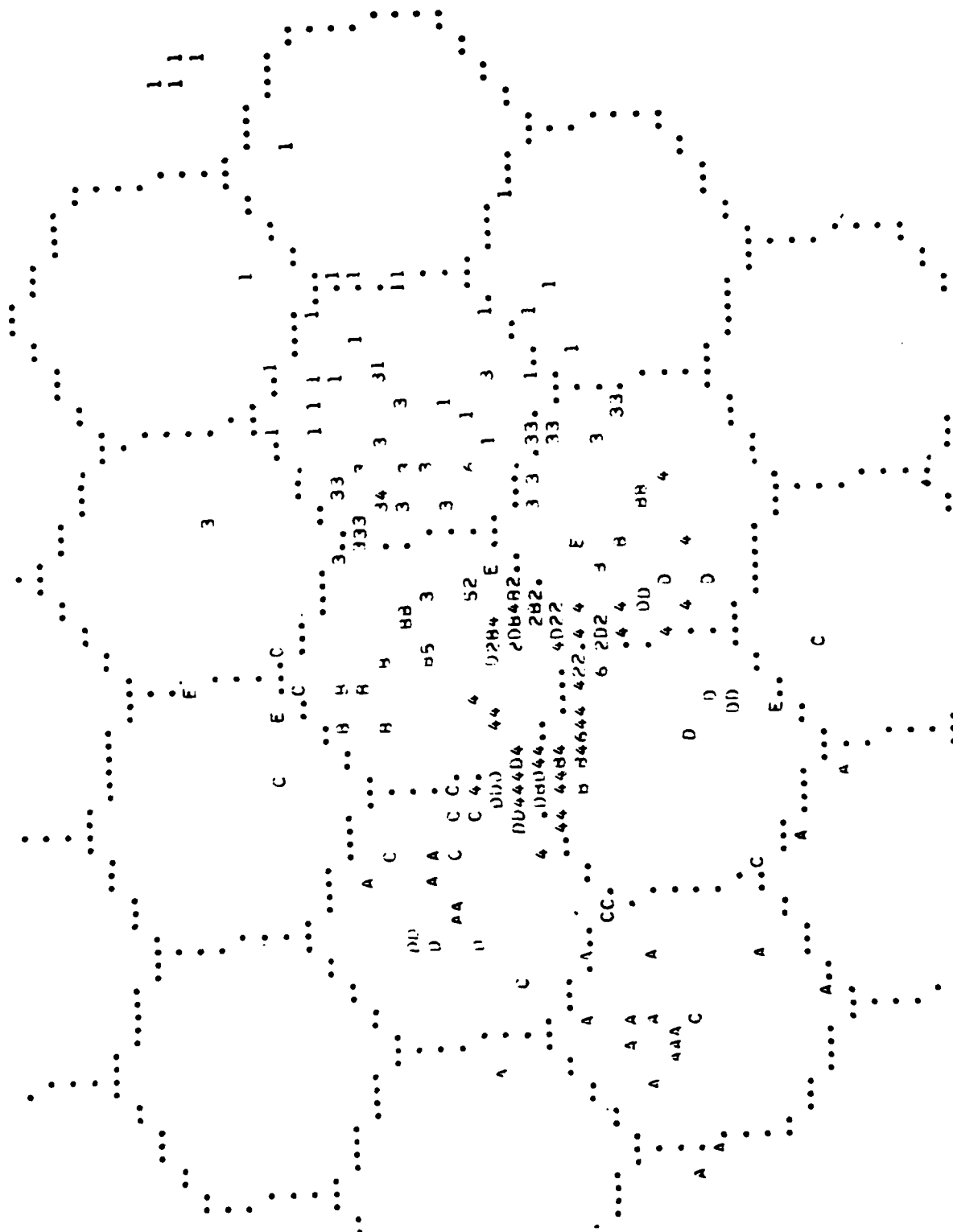
5/10/83





MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A





**Figure F-16. Case I unit positions at 06:00 hours.**



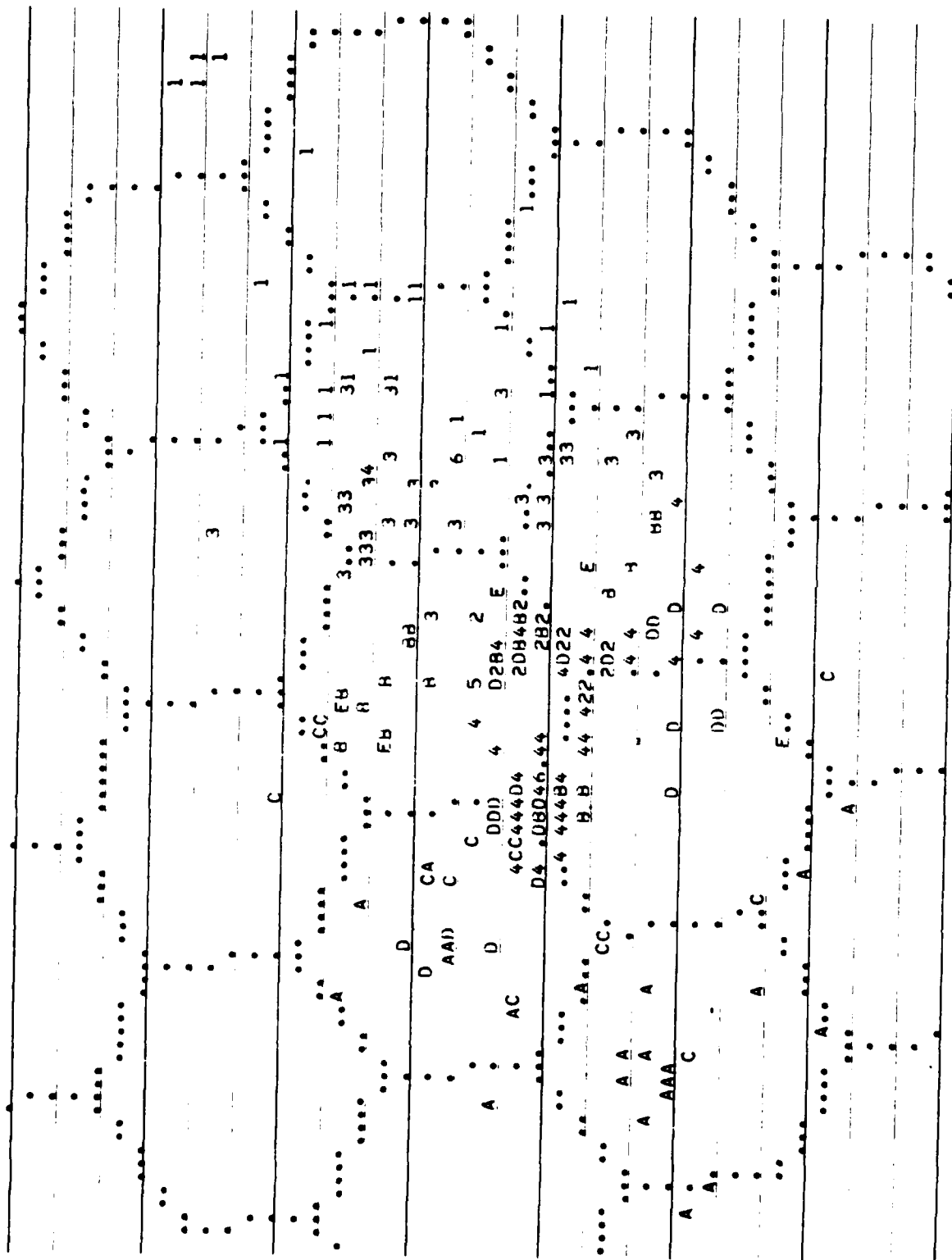


Figure F-17. Case I unit positions at 06:30 hours.

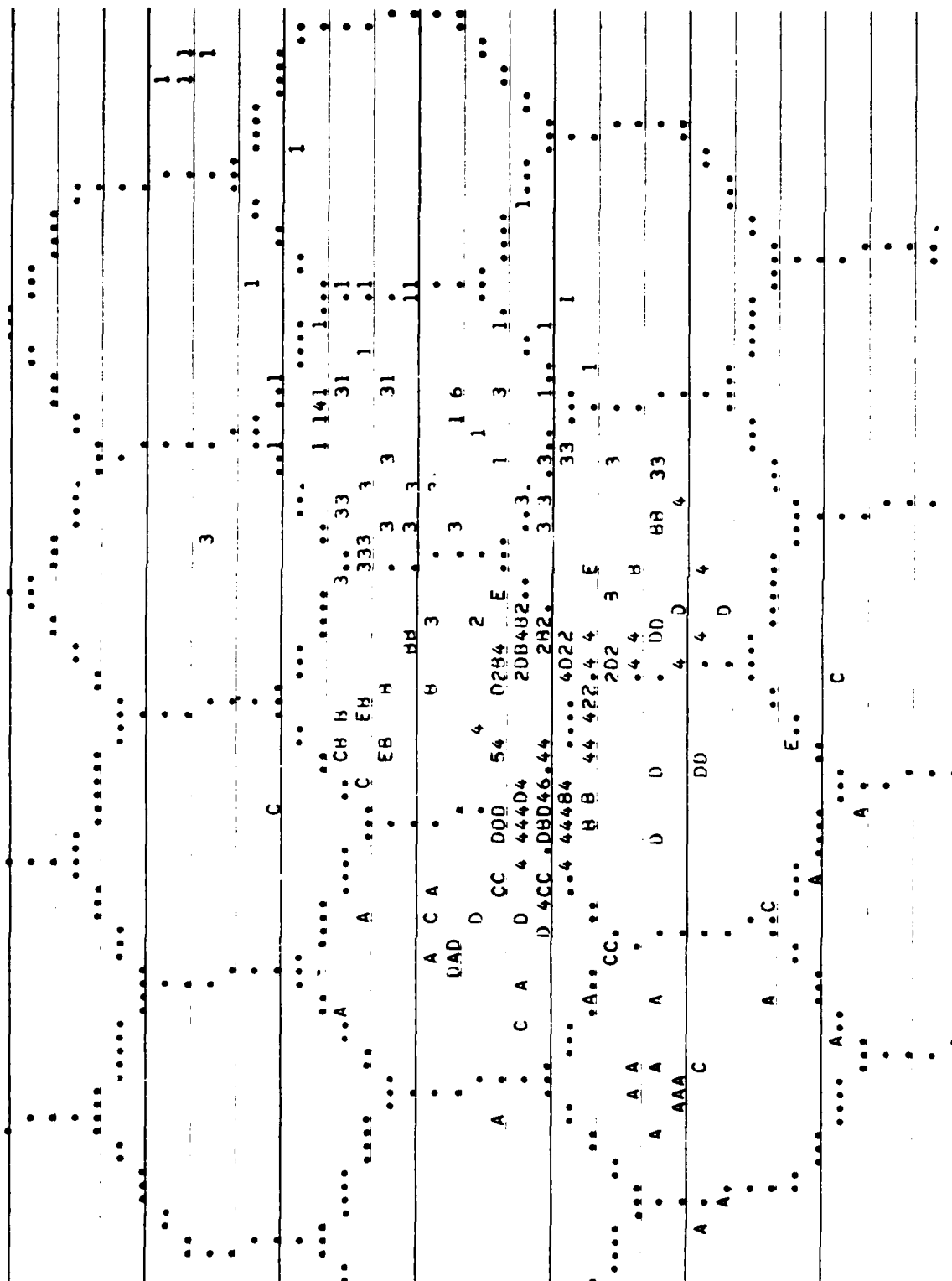
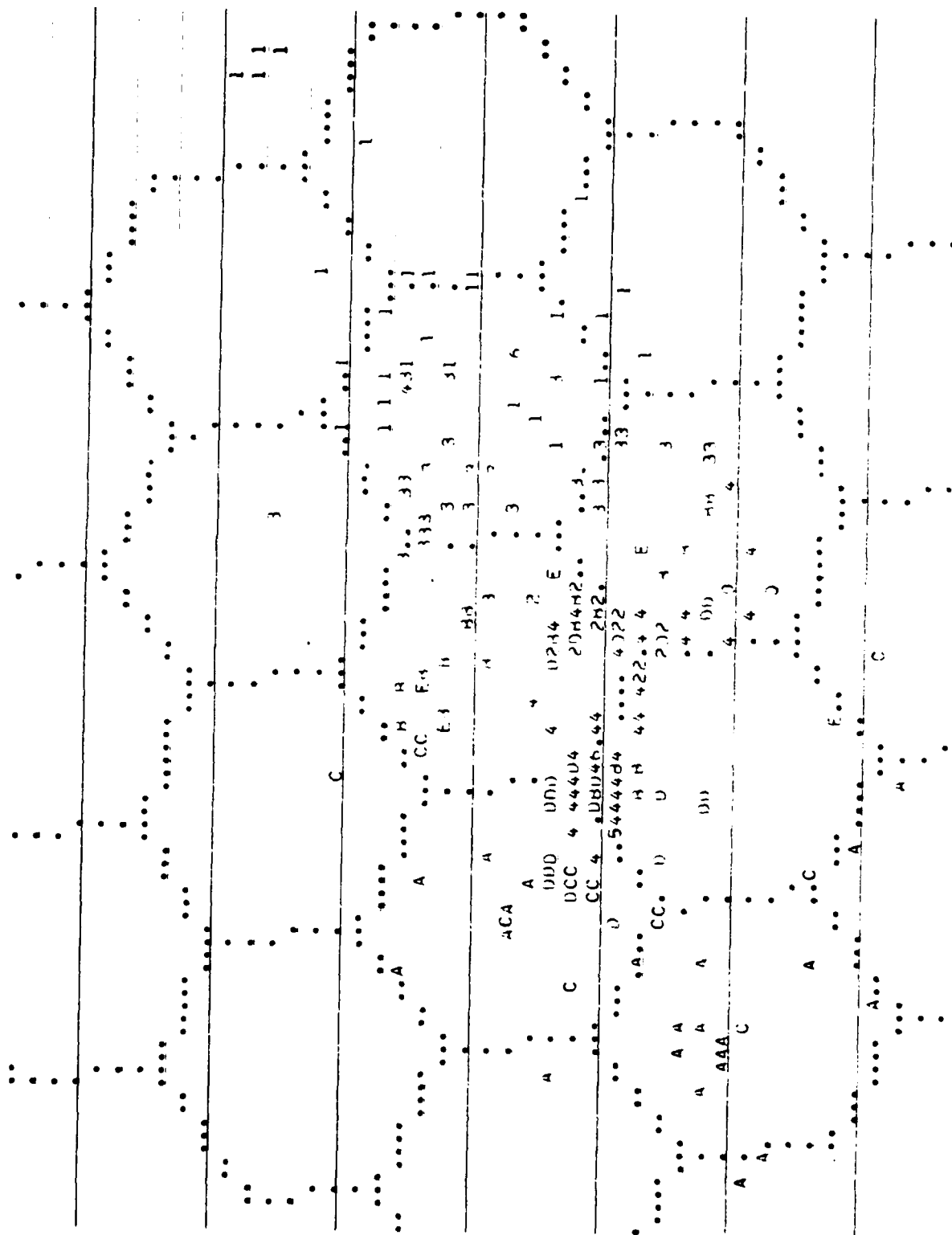
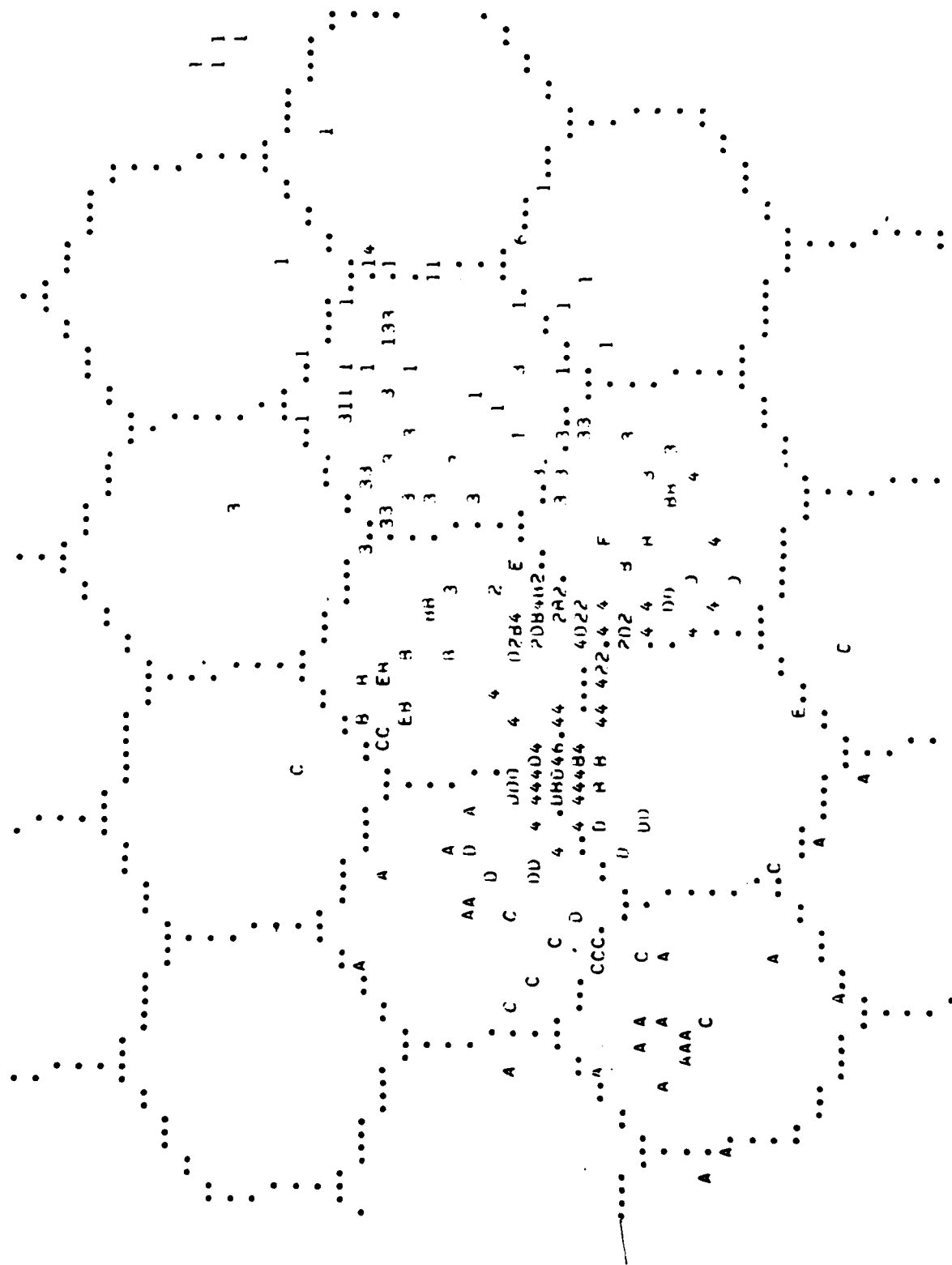
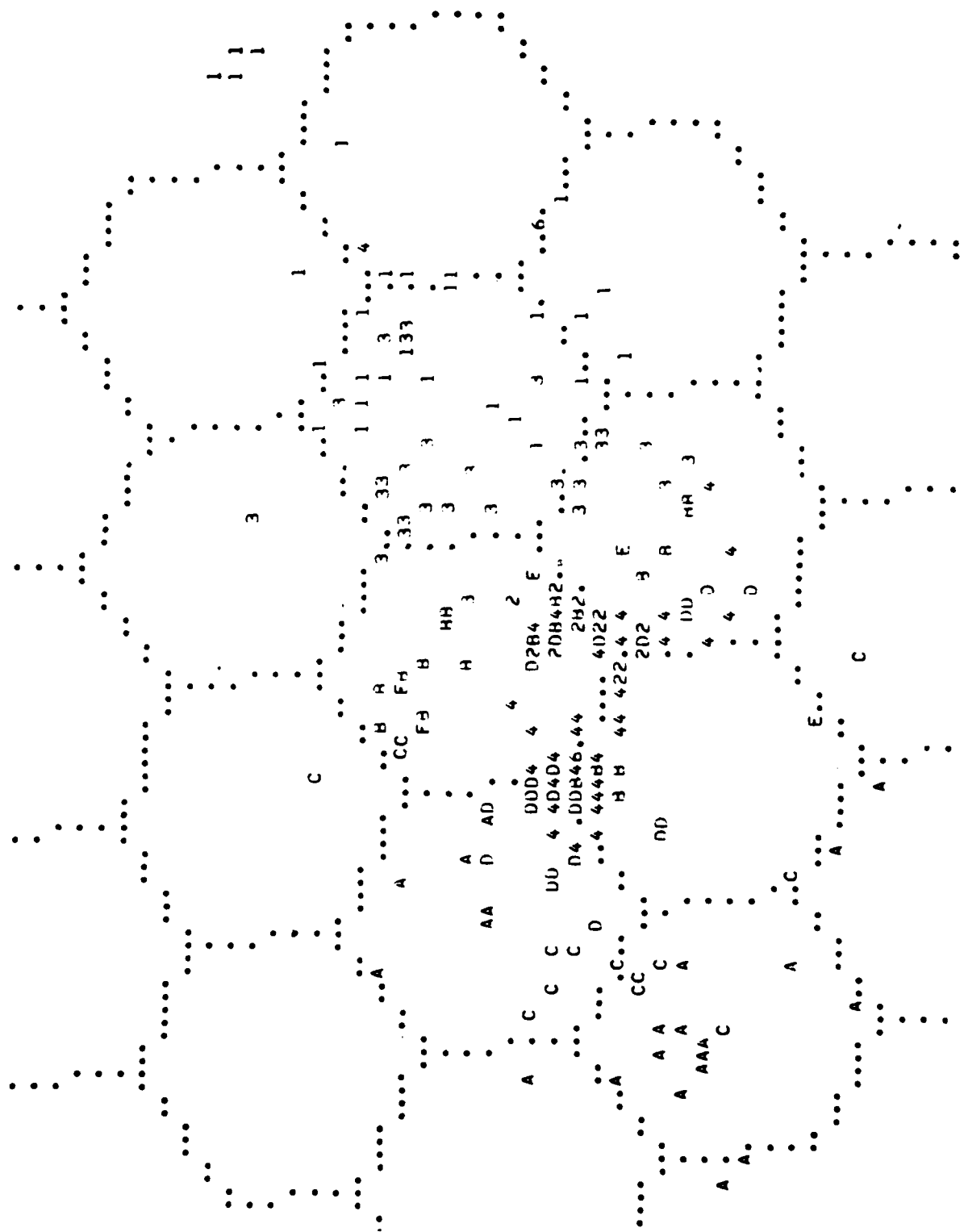


Figure F-18. Case I unit positions at 07:00 hours.







APPENDIX G  
CASE II TACTICAL POSITION MAPS

The 18 maps presented in this appendix show the dynamic combat positions of both combatants at the company/battery level from zero to 0830 hours in one-half hour increments. Legend and other pertinent information concerning these maps is the same as for Case I, Appendix F.

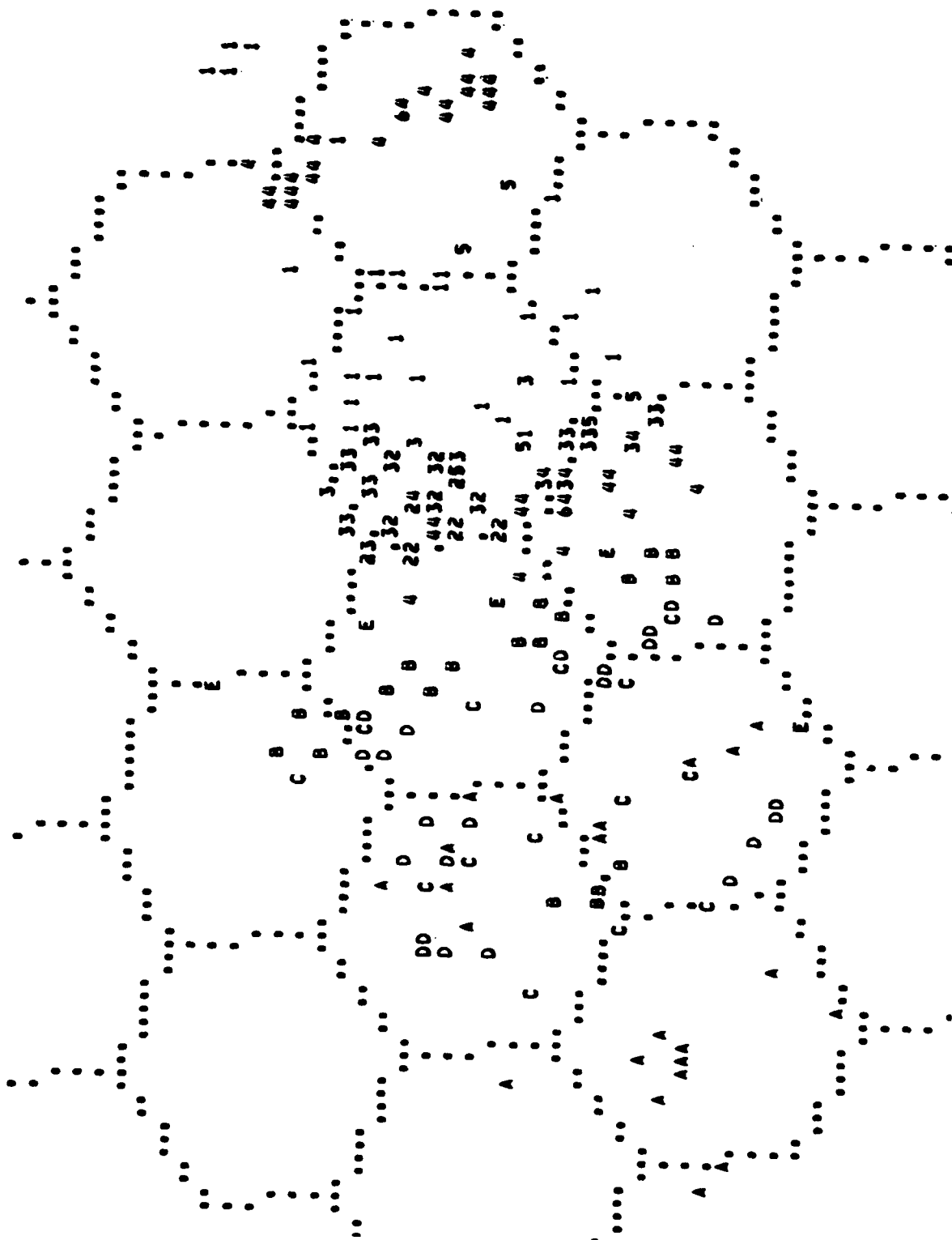


Figure G-1. Case II unit positions at 00:00 hours.

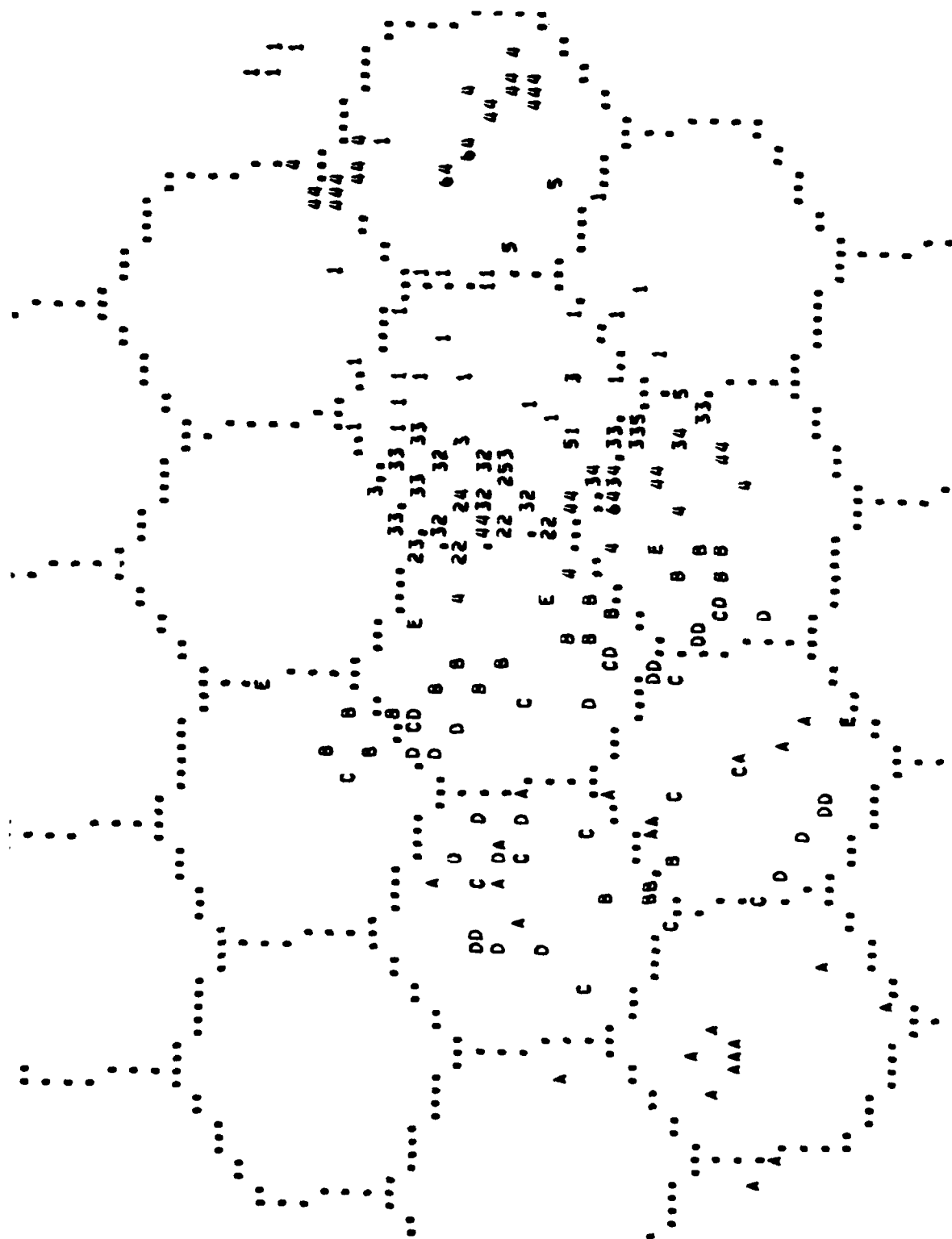


Figure G-2. Case II unit positions at 00:30 hours.



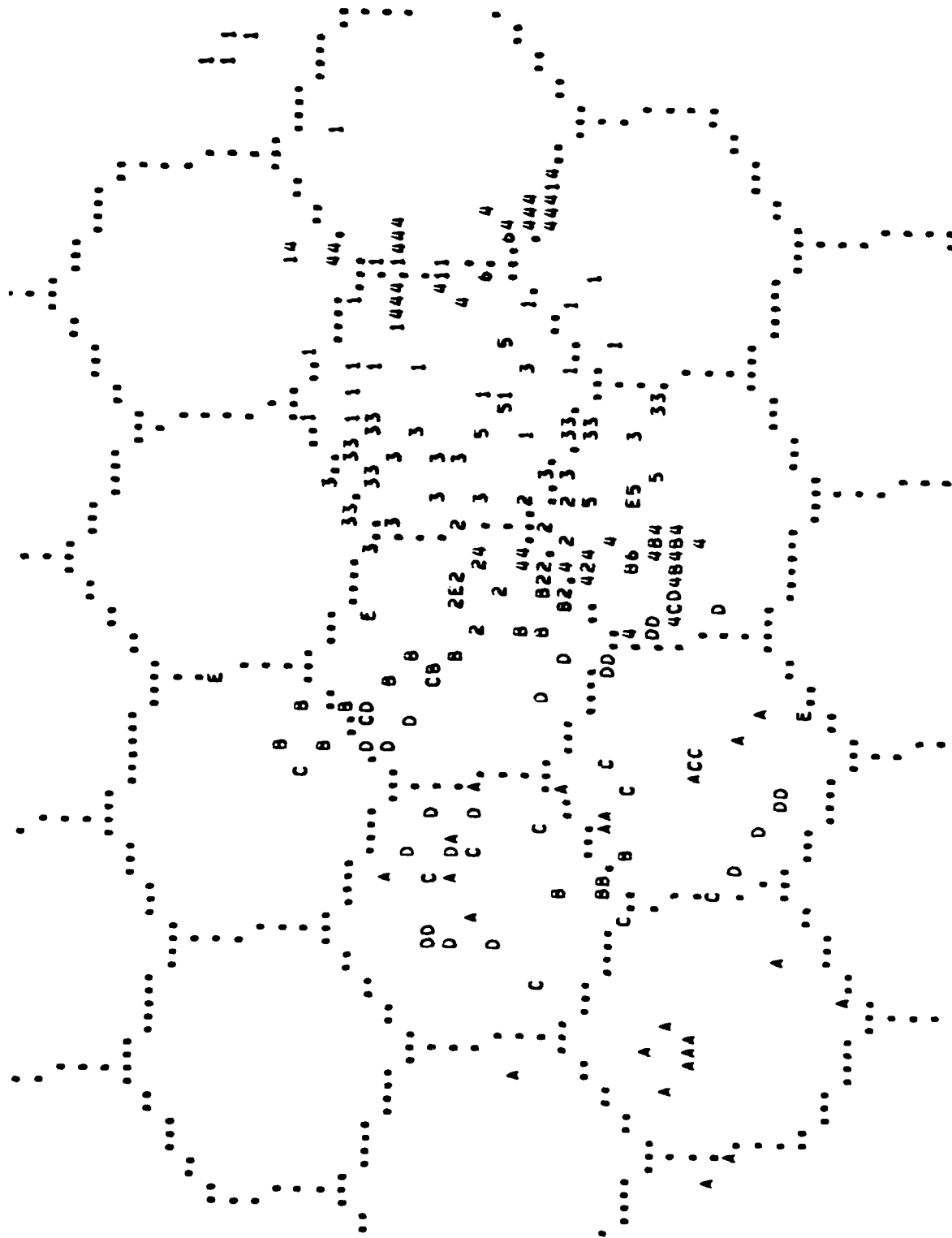


Figure G-3. Case II unit positions at 01:00 hours.

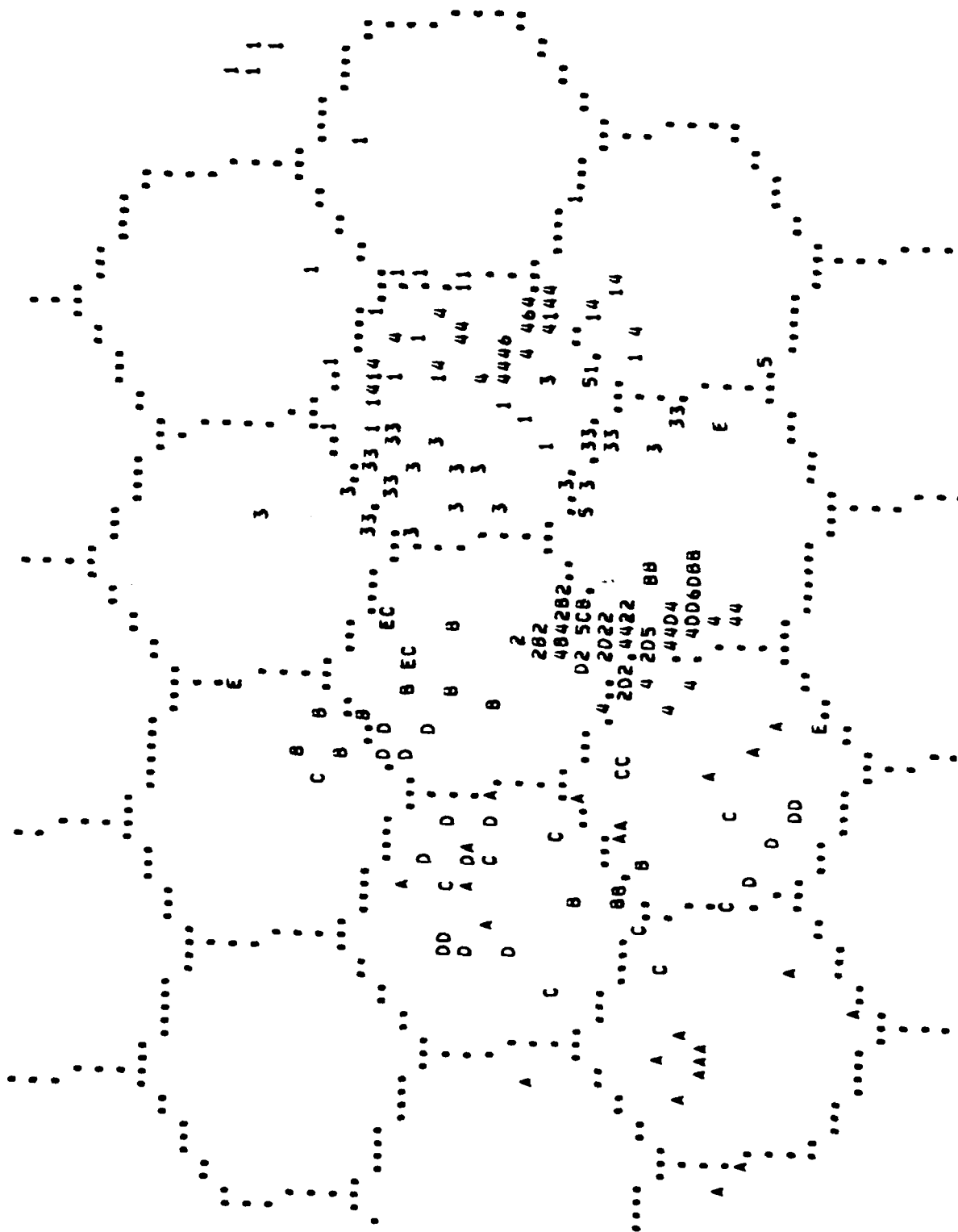
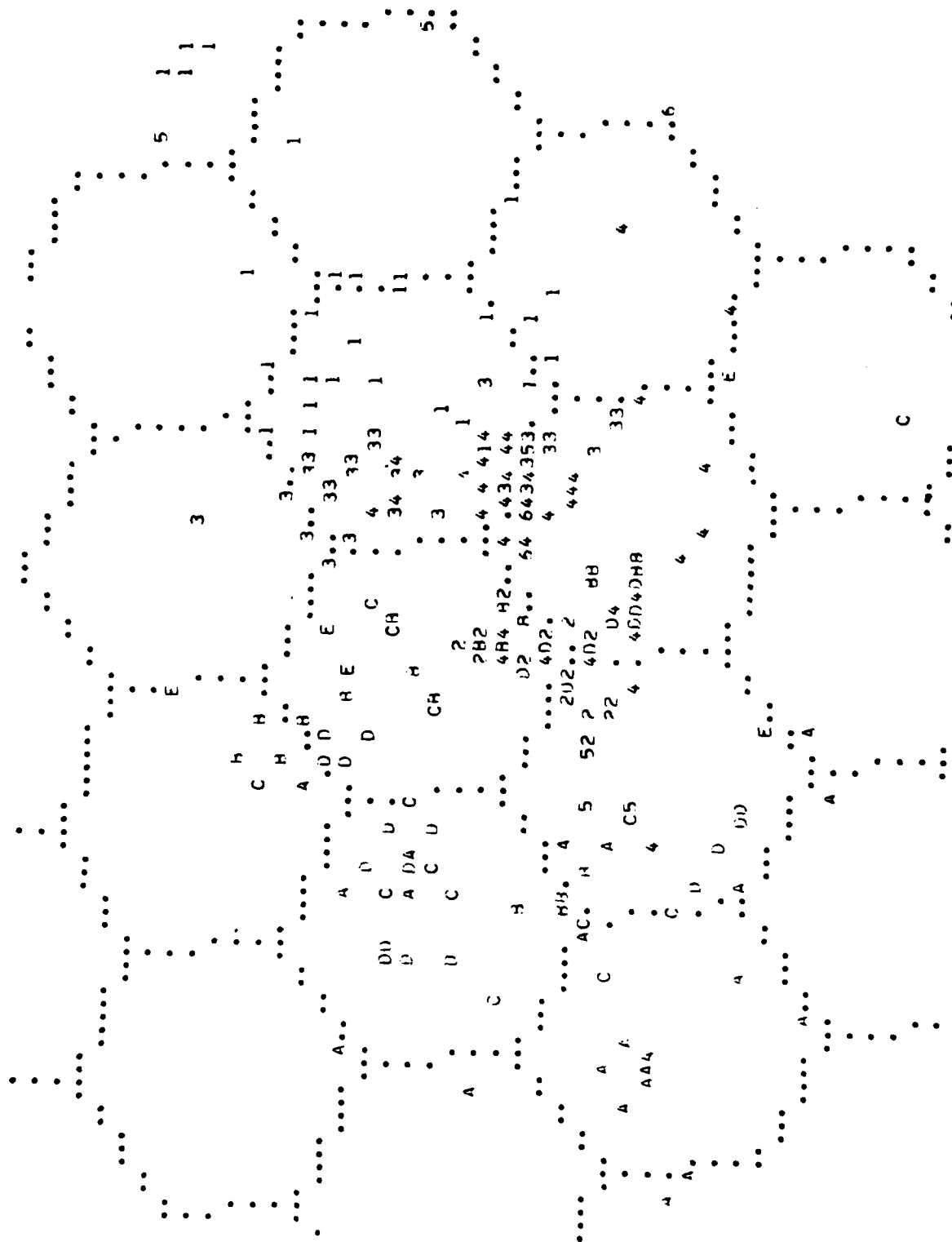




Figure G-5. Case II unit positions at 02:00 hours.



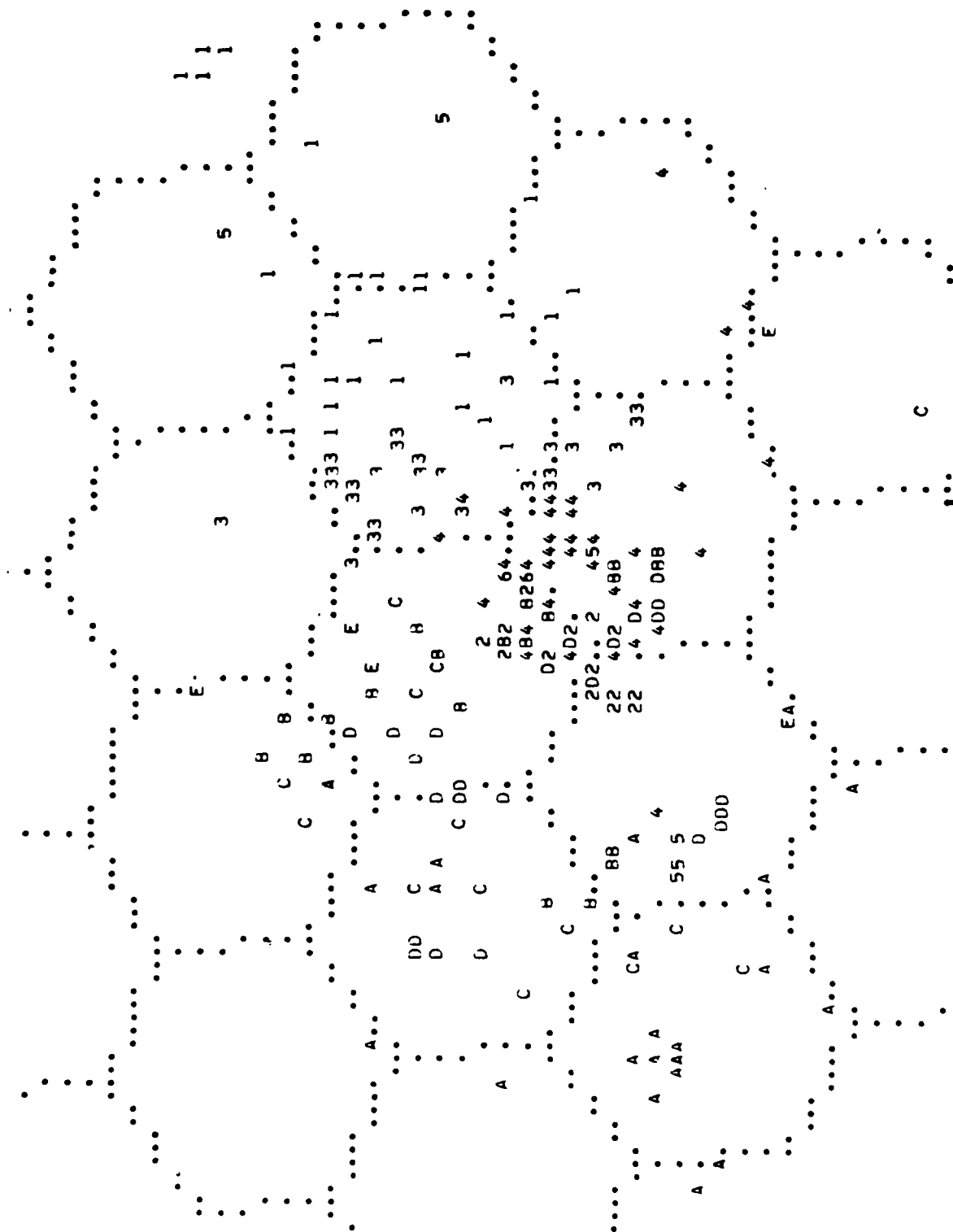
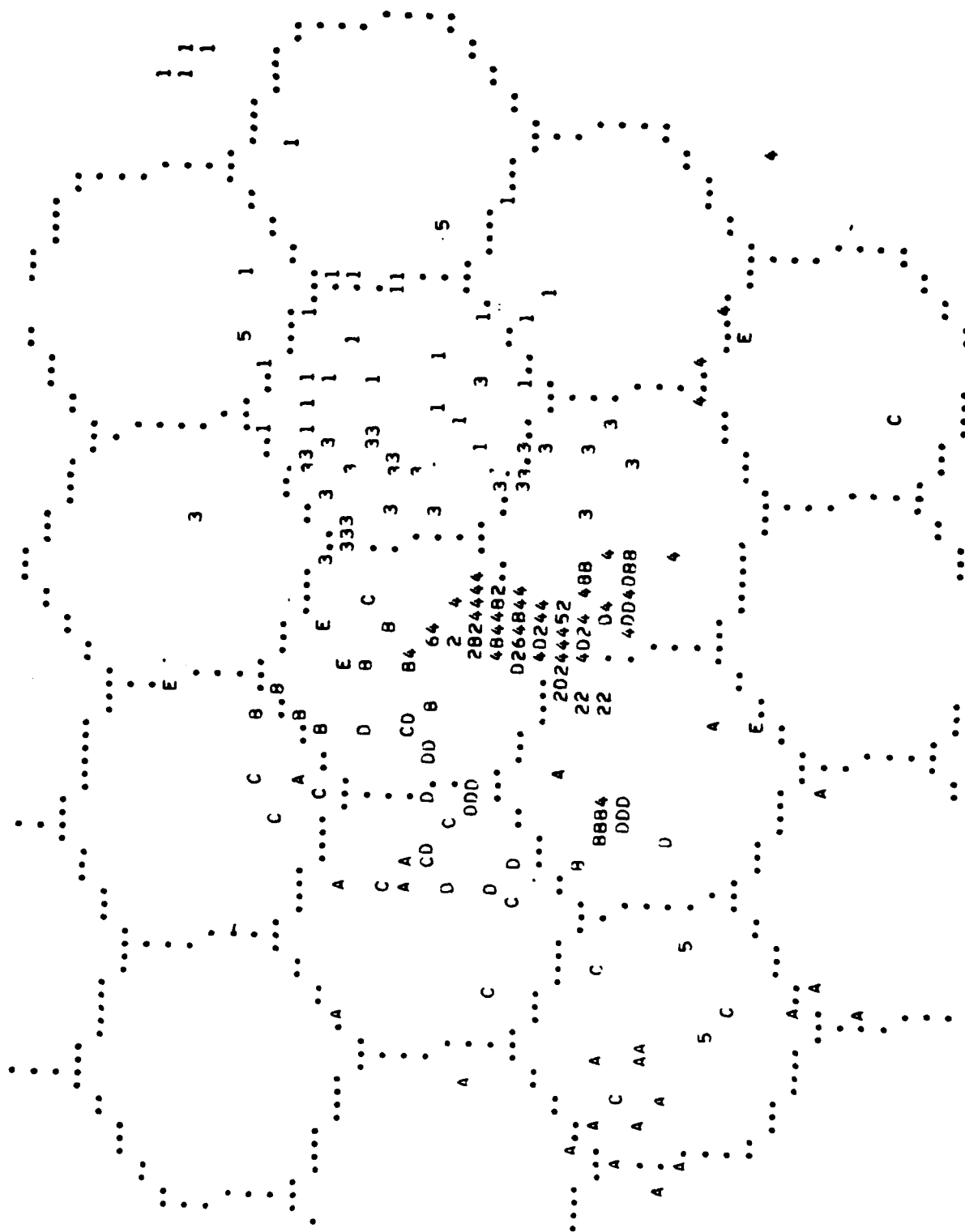


Figure G-7. Case II unit positions at 03:00 hours.



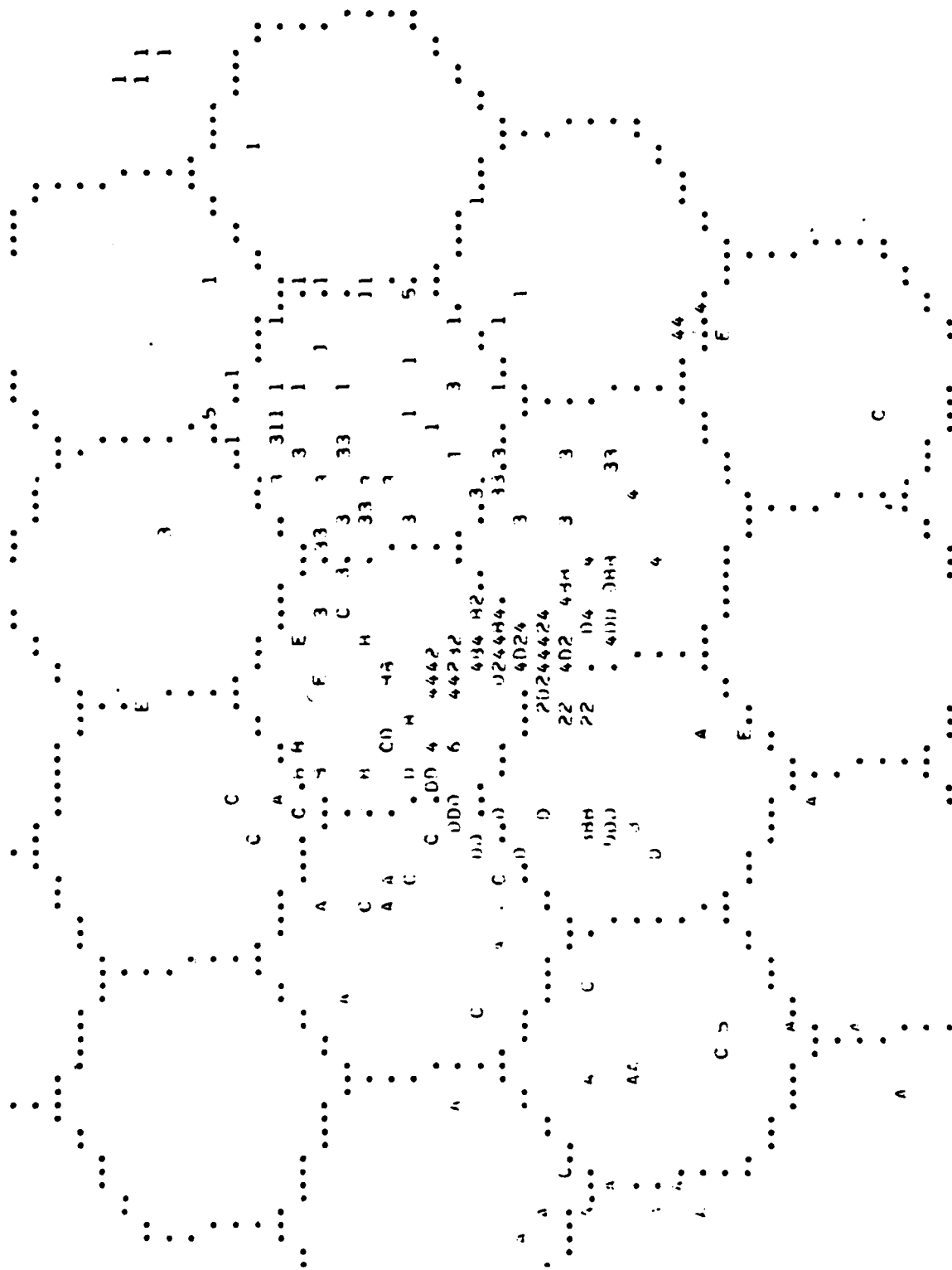


Figure G-9. Case II unit positions at 04:00 hours.

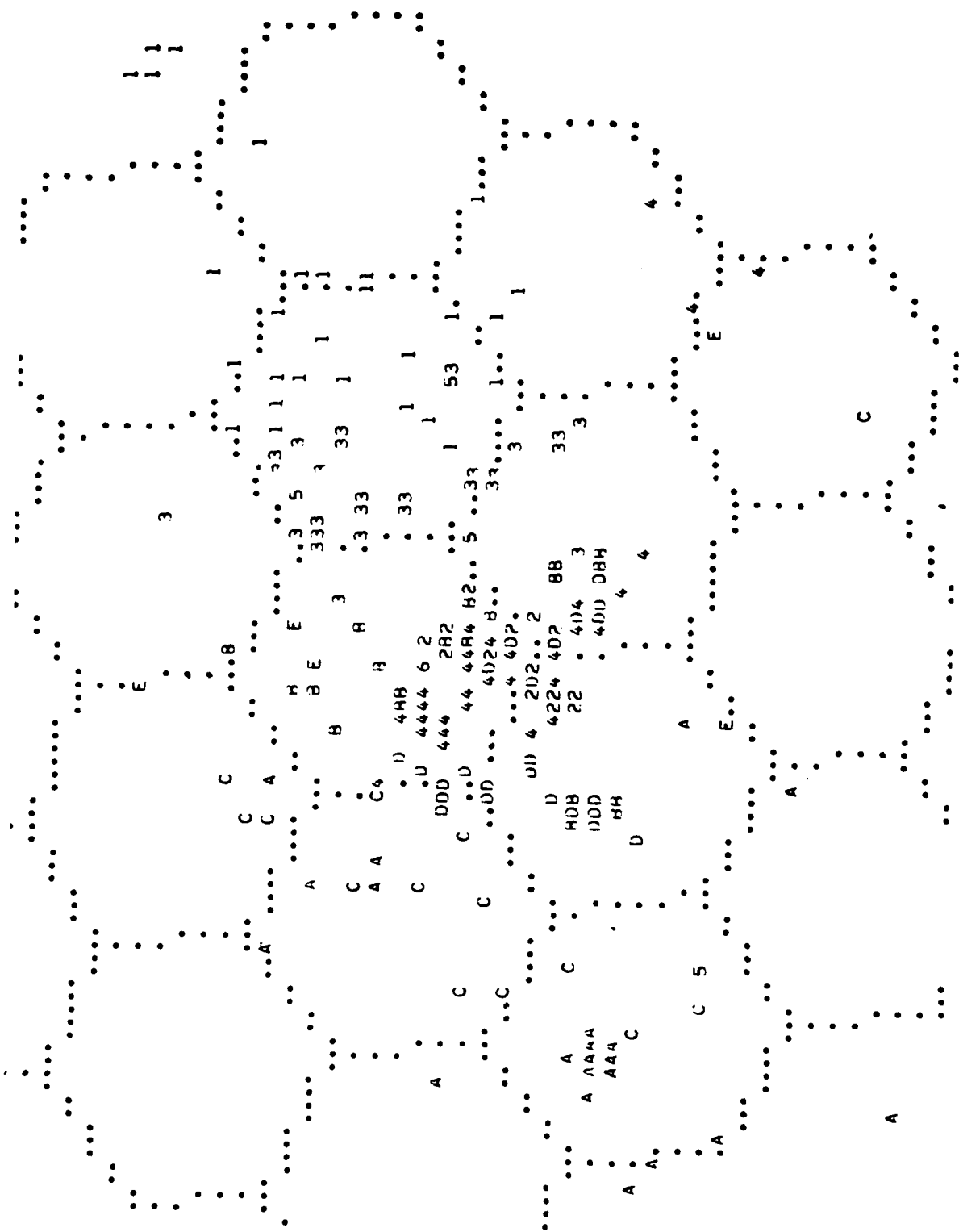


Figure G-10. Case II unit positions at 04:30 hours.



**B**

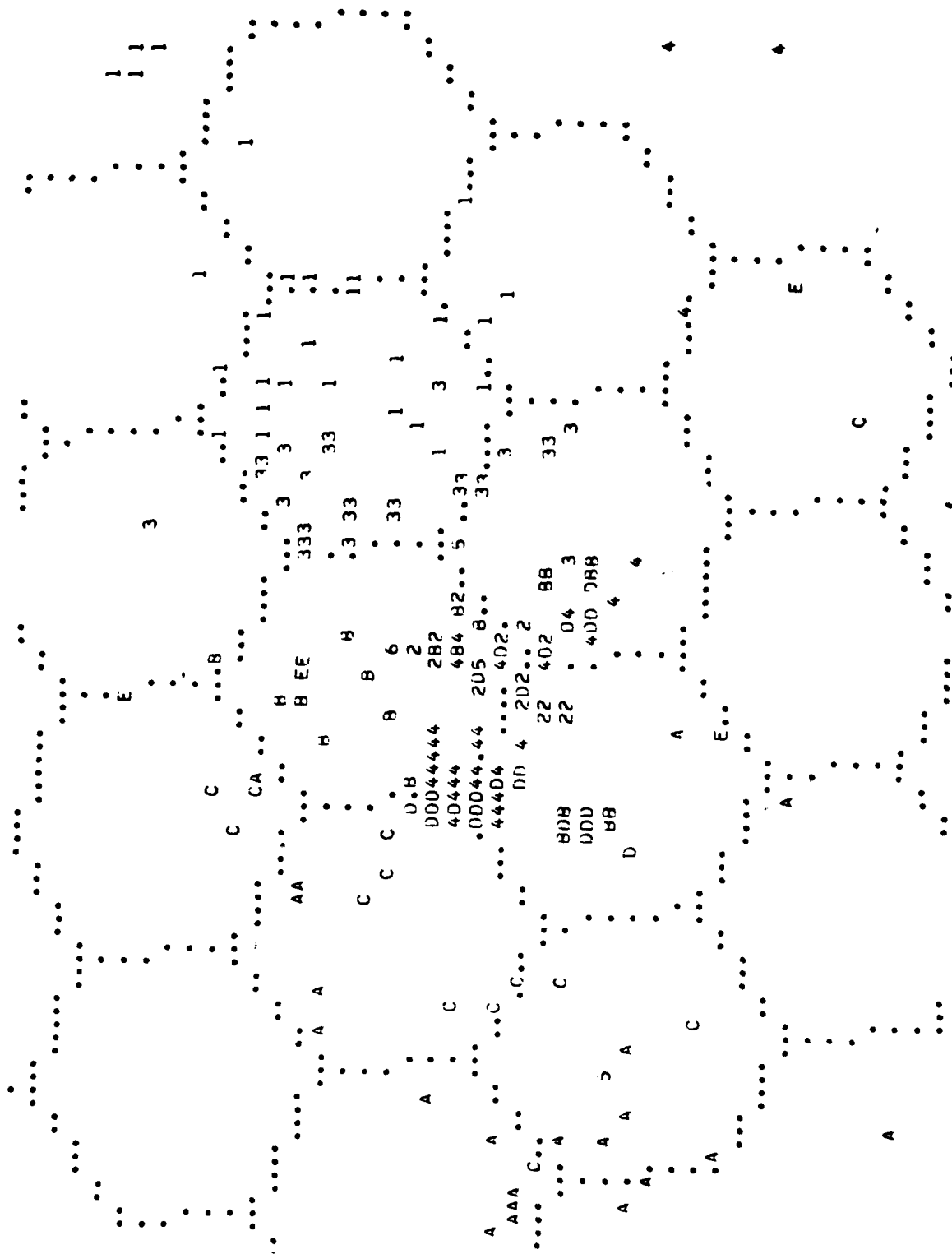


Figure G-12. Case II unit positions at 05:30 hours.

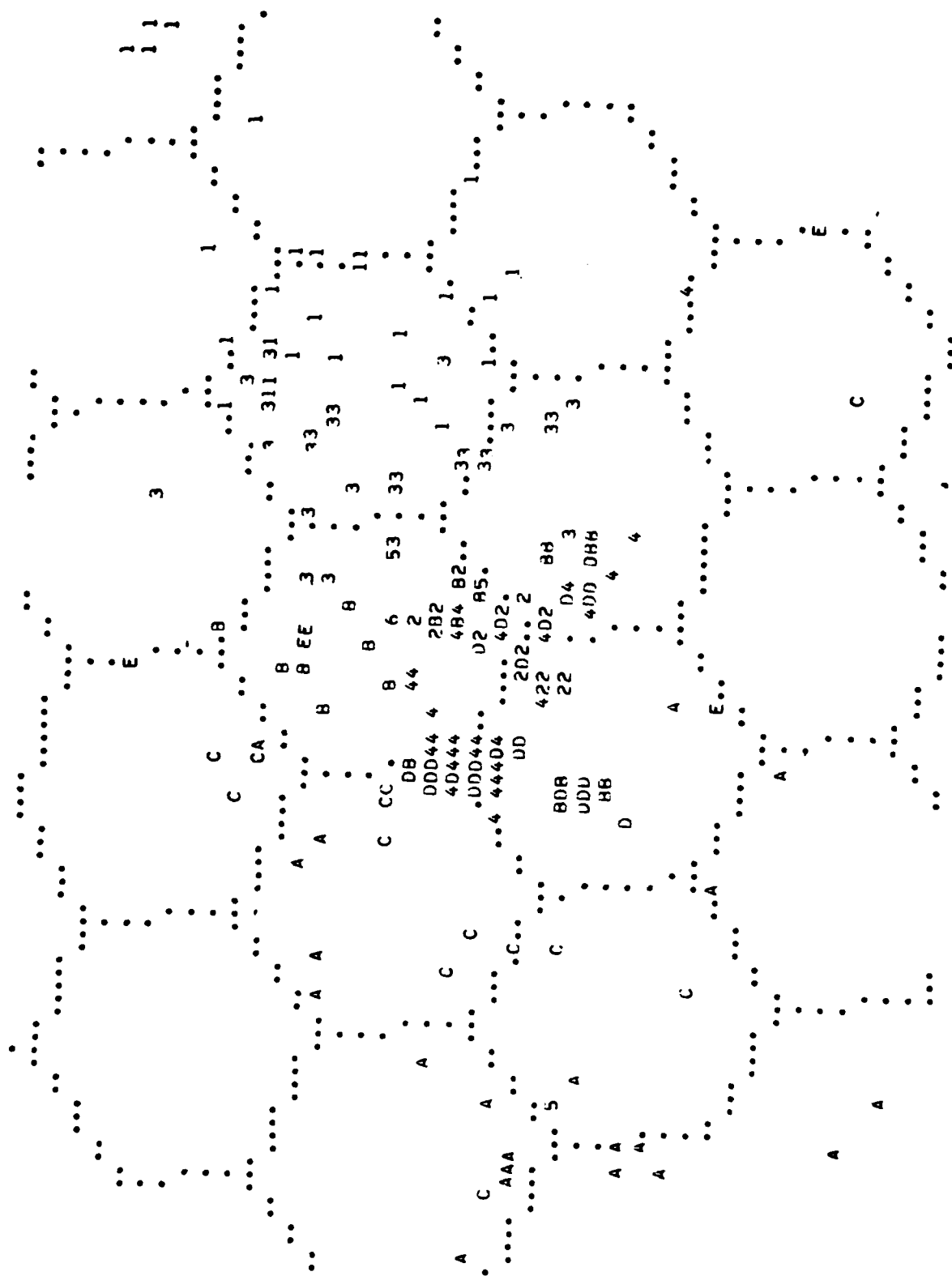


Figure G-13. Case II unit positions at 06:00 hours.

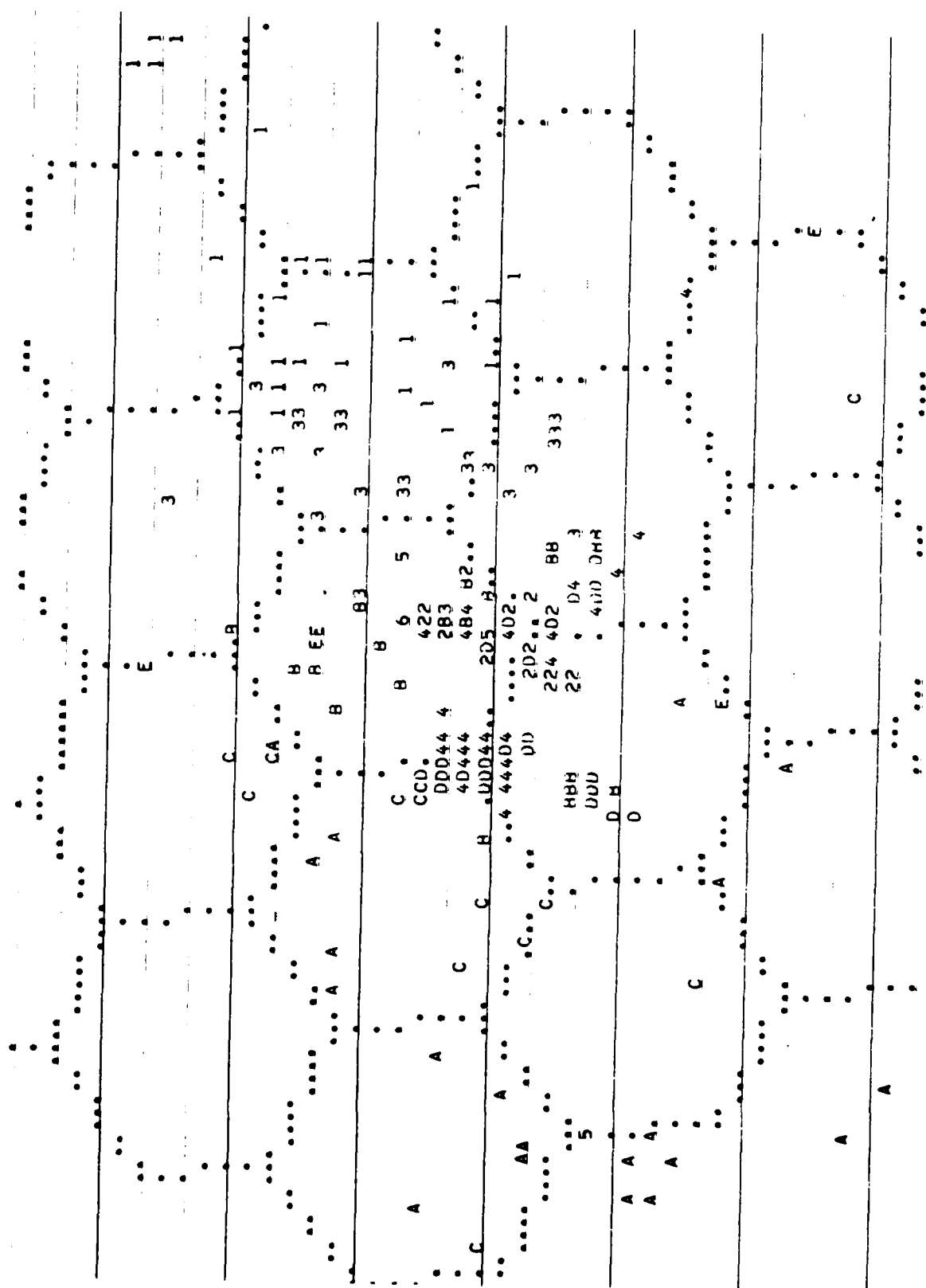


Figure G-14. Case II unit positions at 06:30 hours.

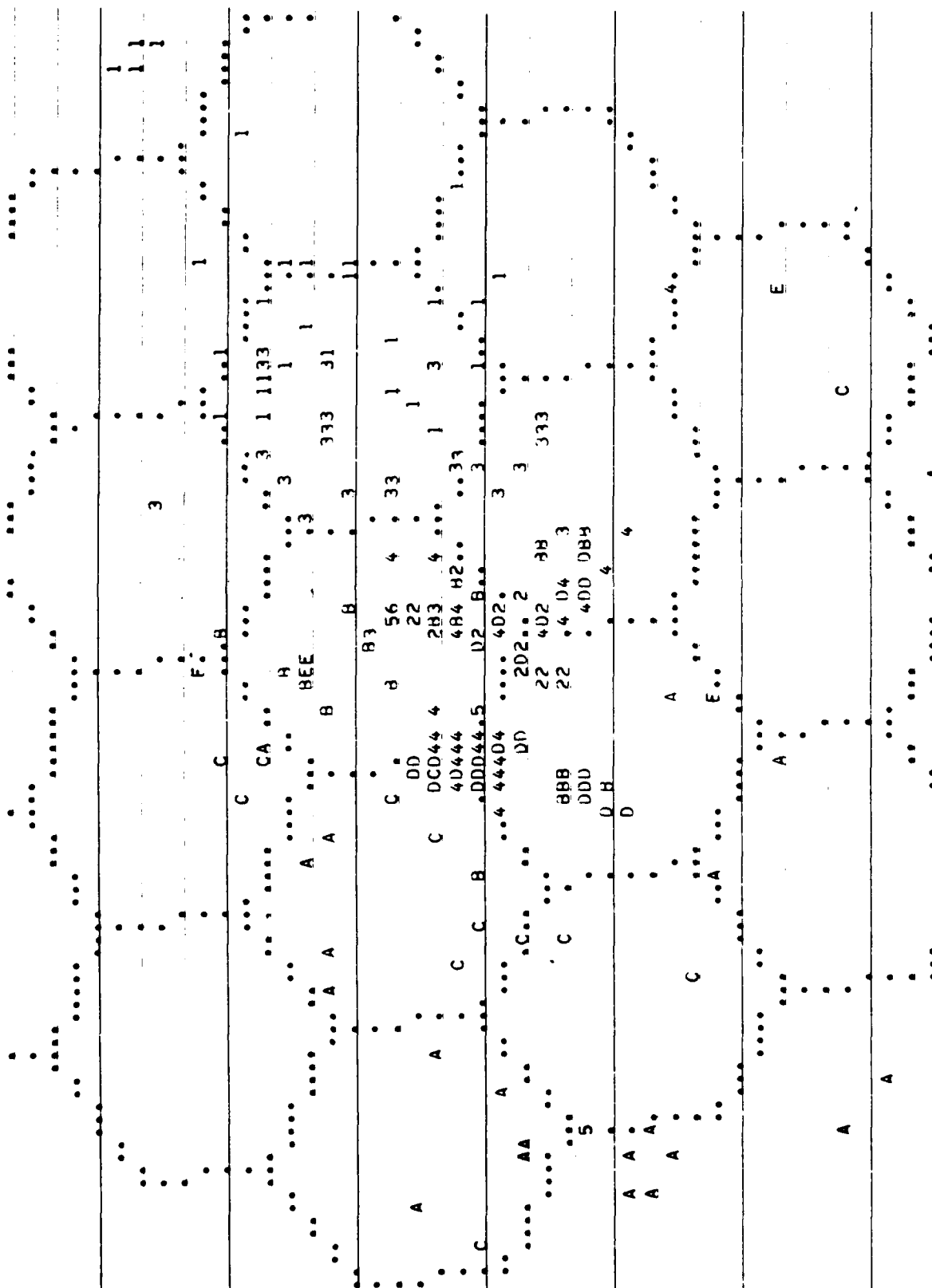


Figure G-15. Case II unit positions at 07:00 hours.

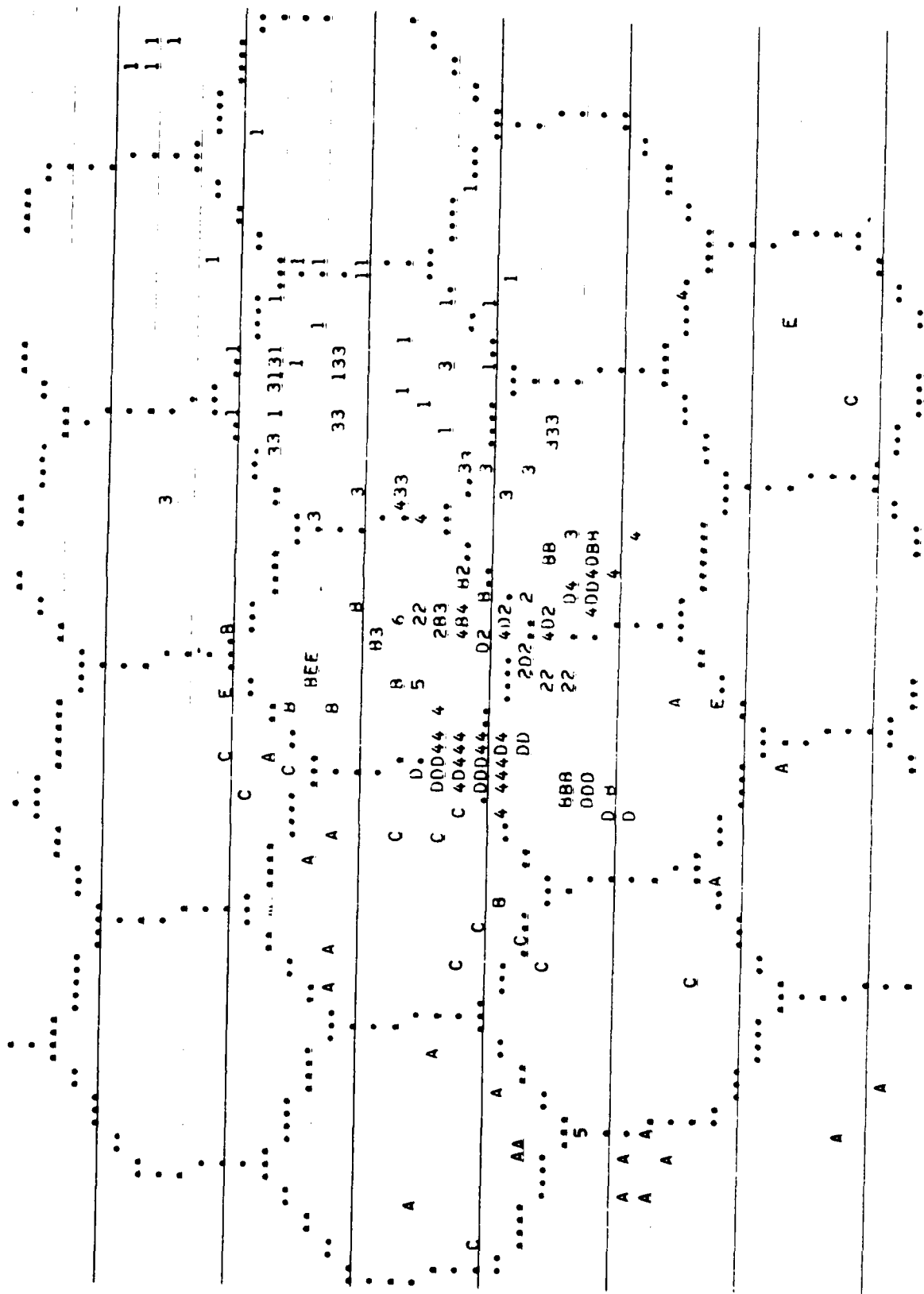
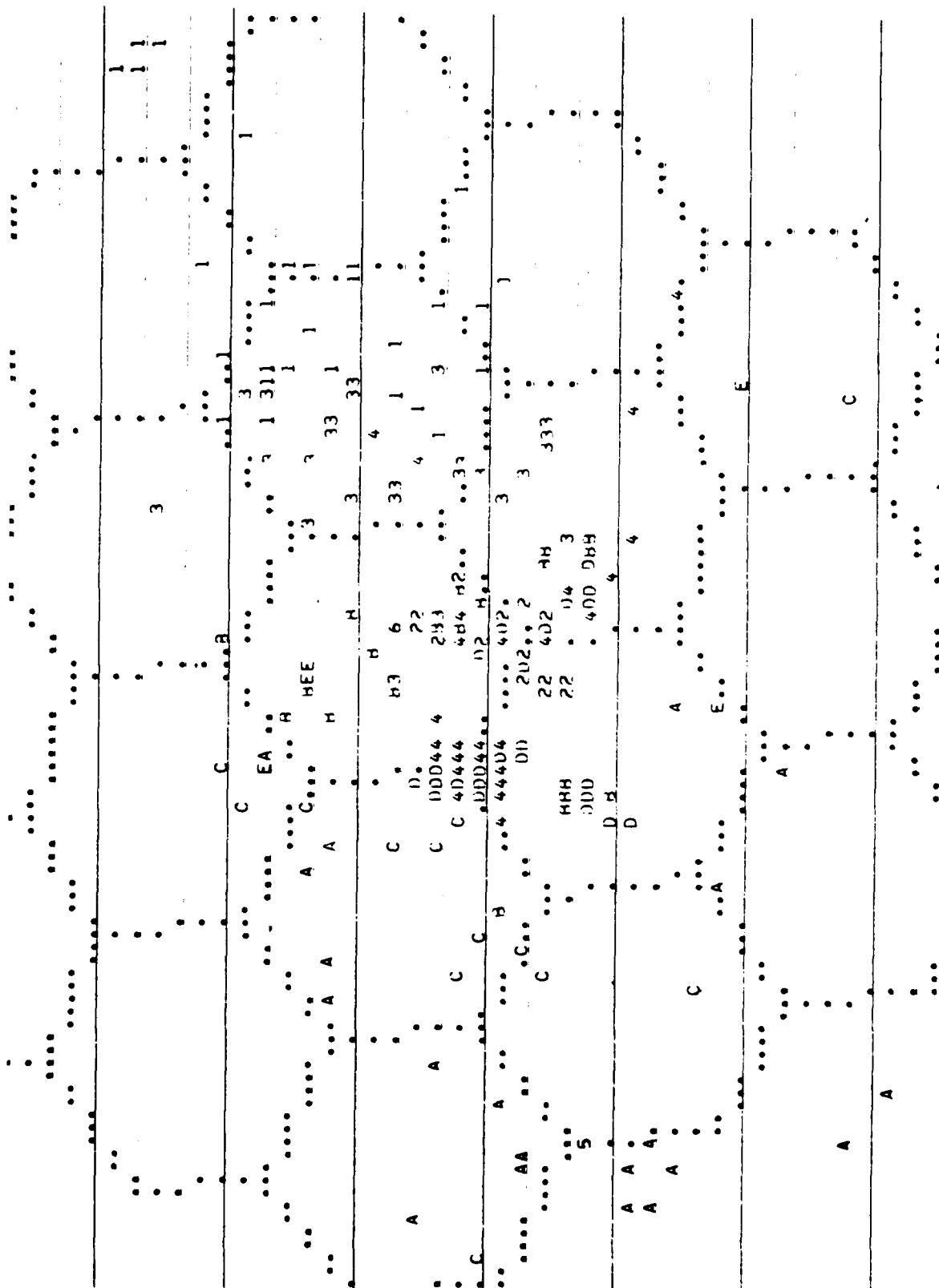


Figure G-16. Case II unit positions at 07:30 hours.



**Figure G-17. Case II unit positions at 08:00 hours.**

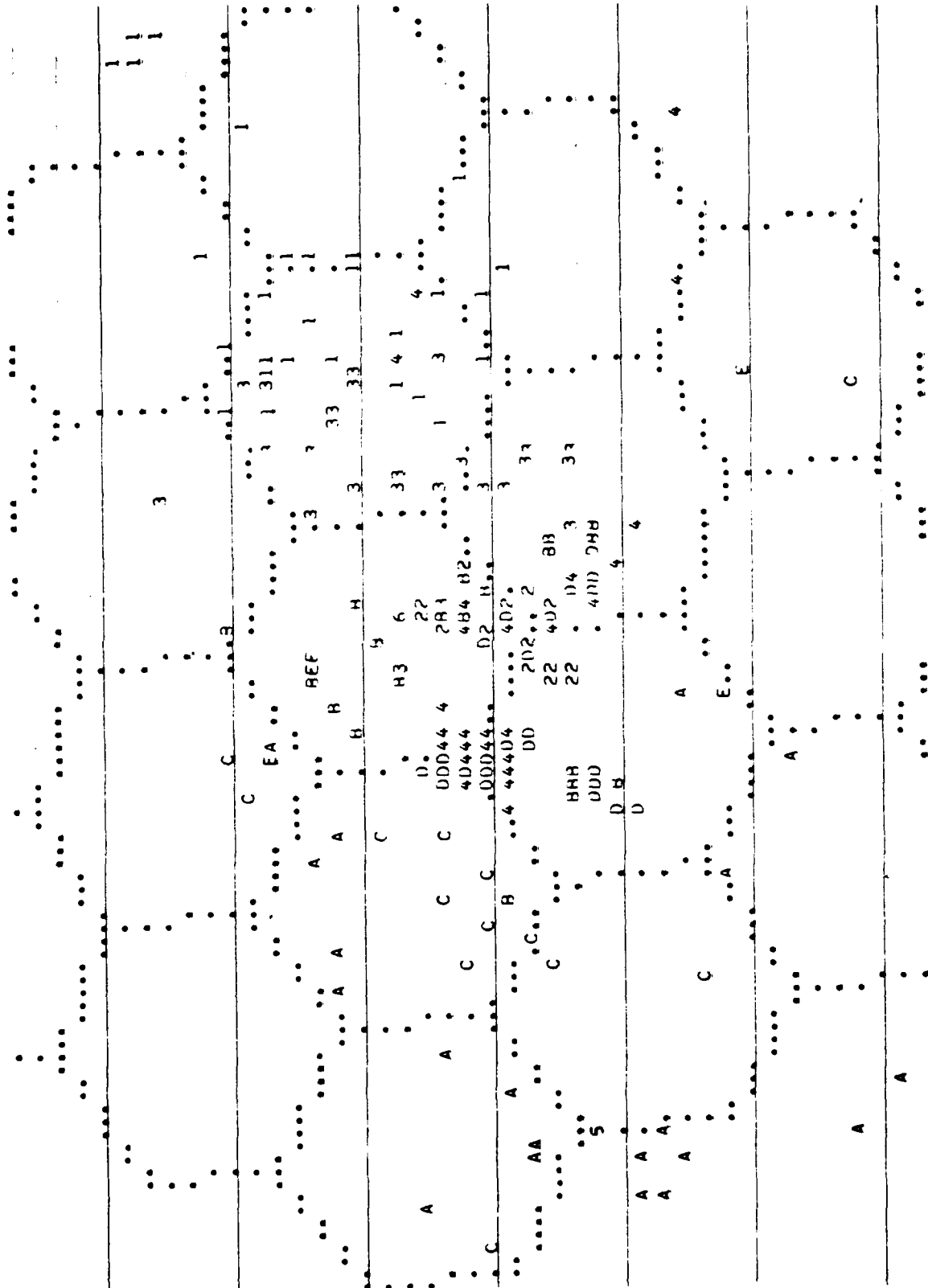


Figure G-18. Case II unit positions at 08:30 hours.



APPENDIX H  
CASE III TACTICAL POSITION MAPS

The 18 maps presented in this appendix show the dynamic combat positions of both combatants at the company/battery level from zero to 0830 hours in one-half hour increments. Legend and other pertinent information concerning these maps is the same as for Case I, Appendix F.

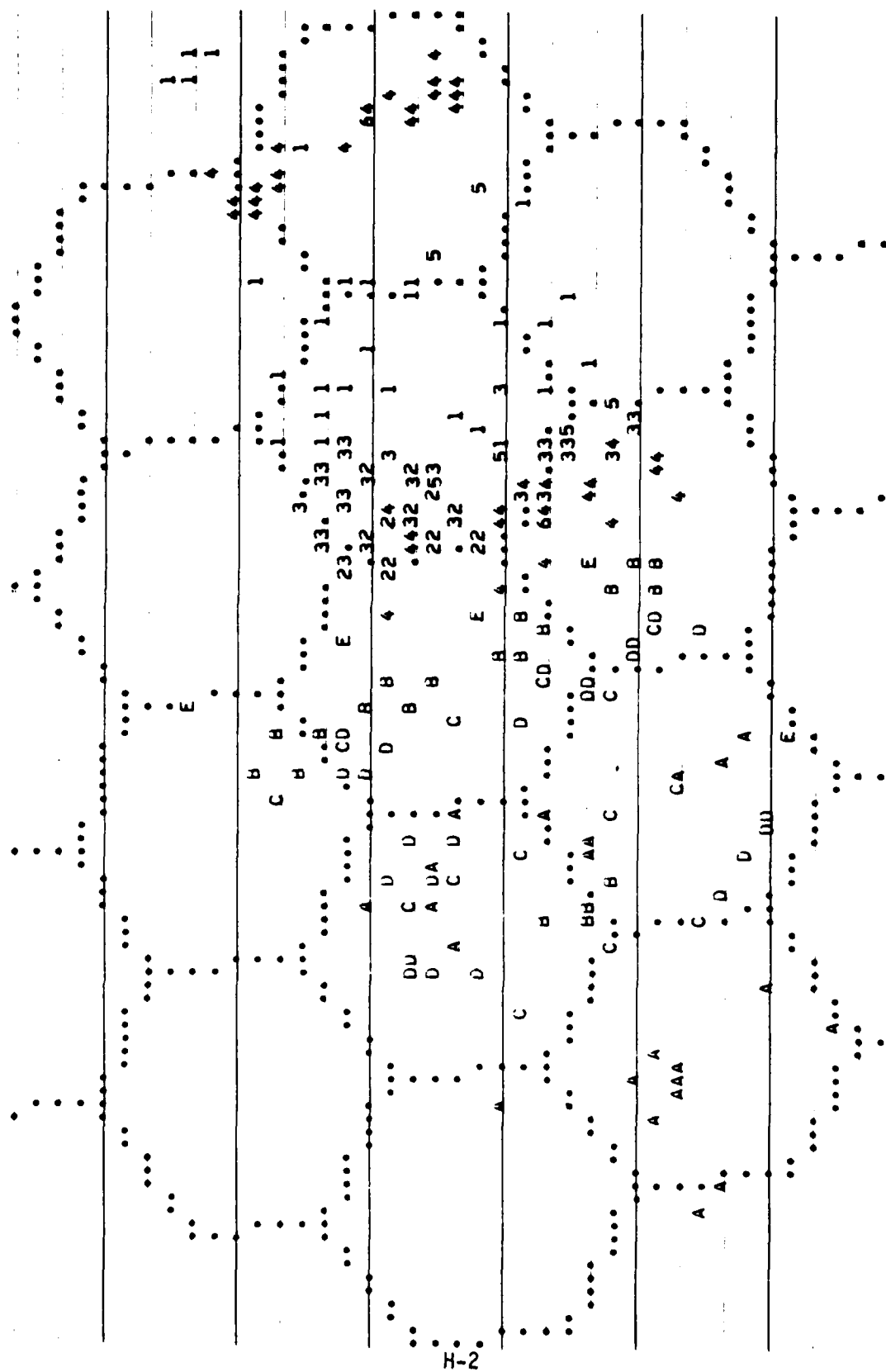


Figure H-1. Case III unit positions at 00:00 hours.

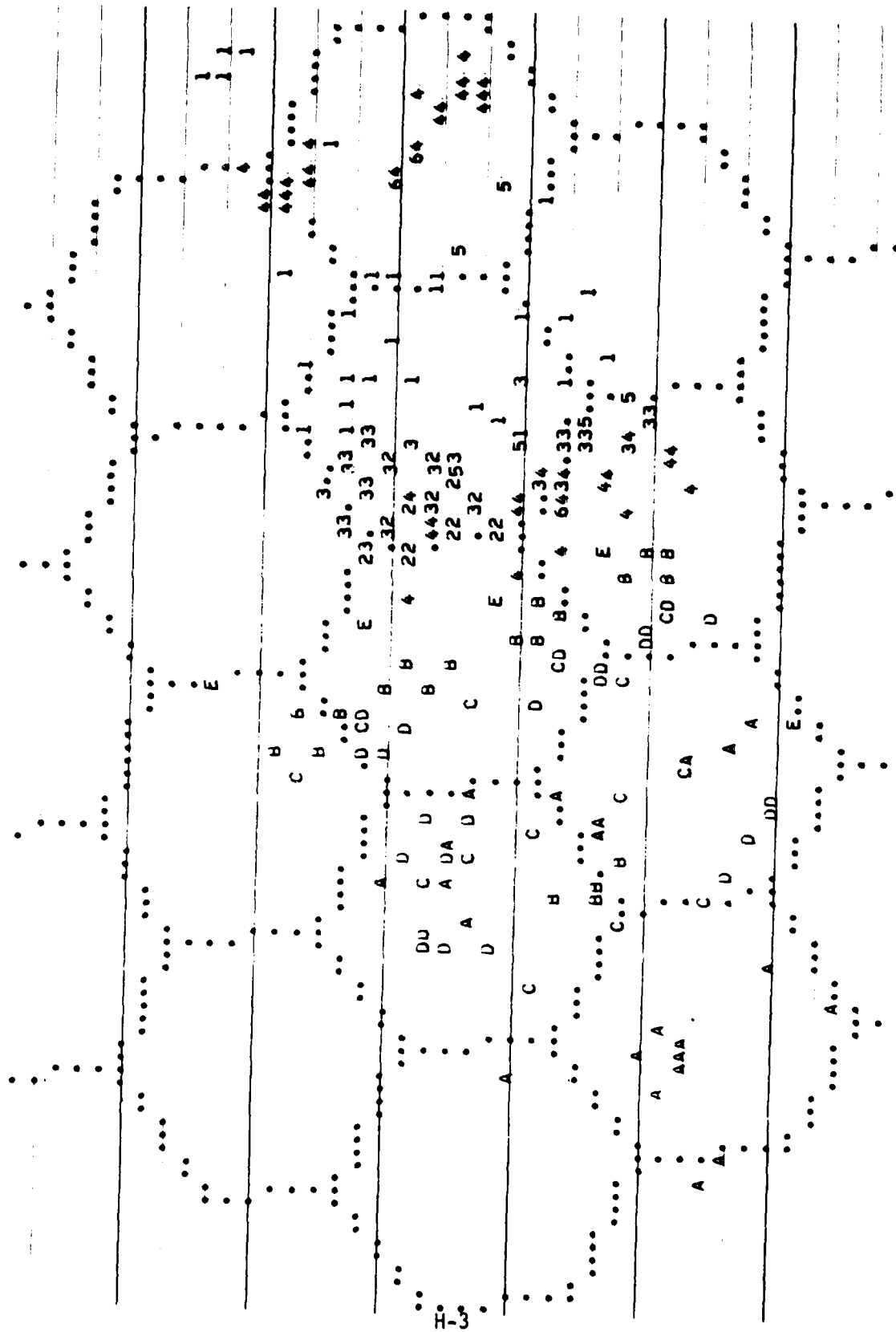


Figure H-2. Case III unit positions at 00:30 hours.

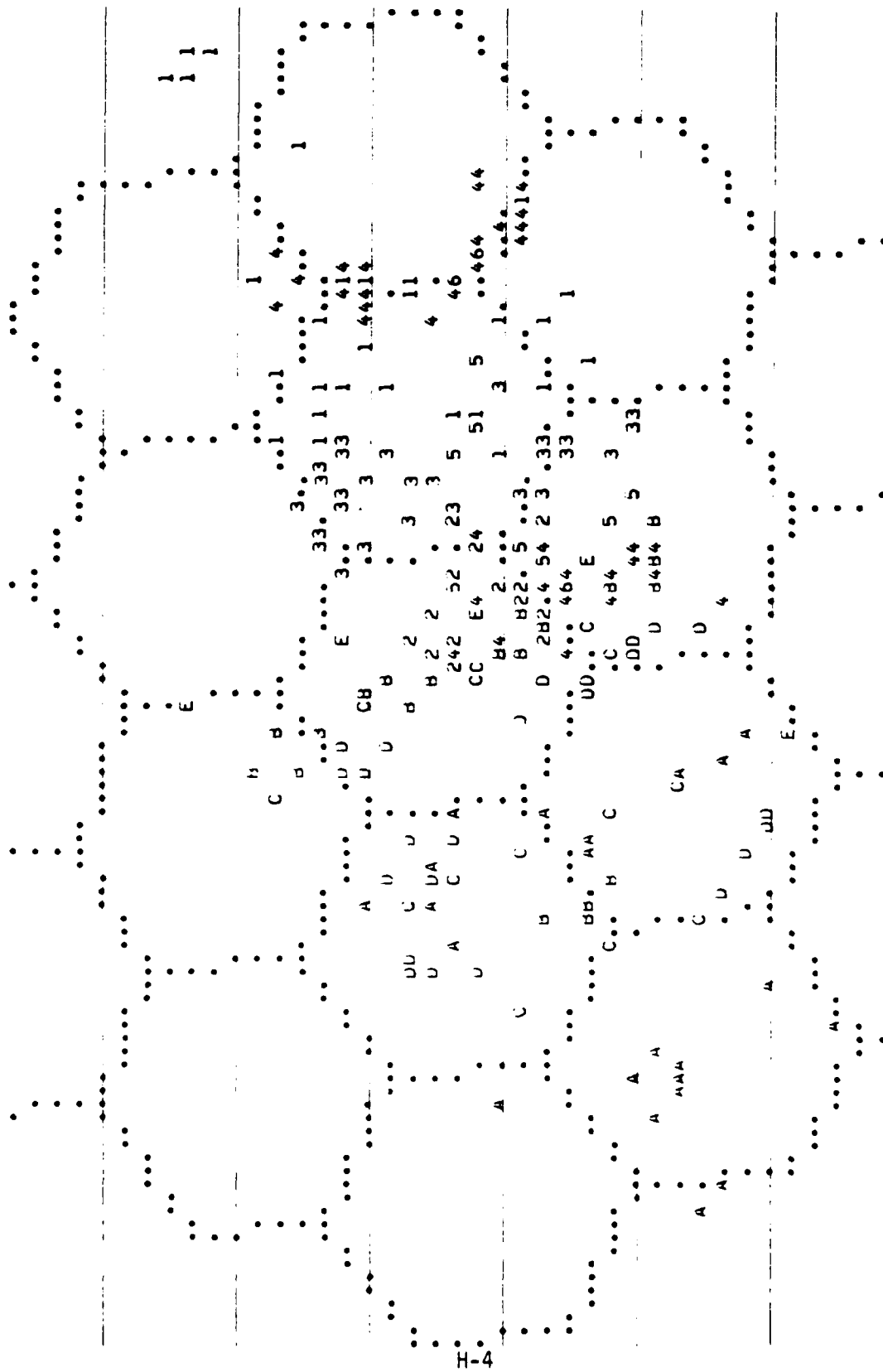


Figure H-3. Case III unit positions at 01:00 hours.

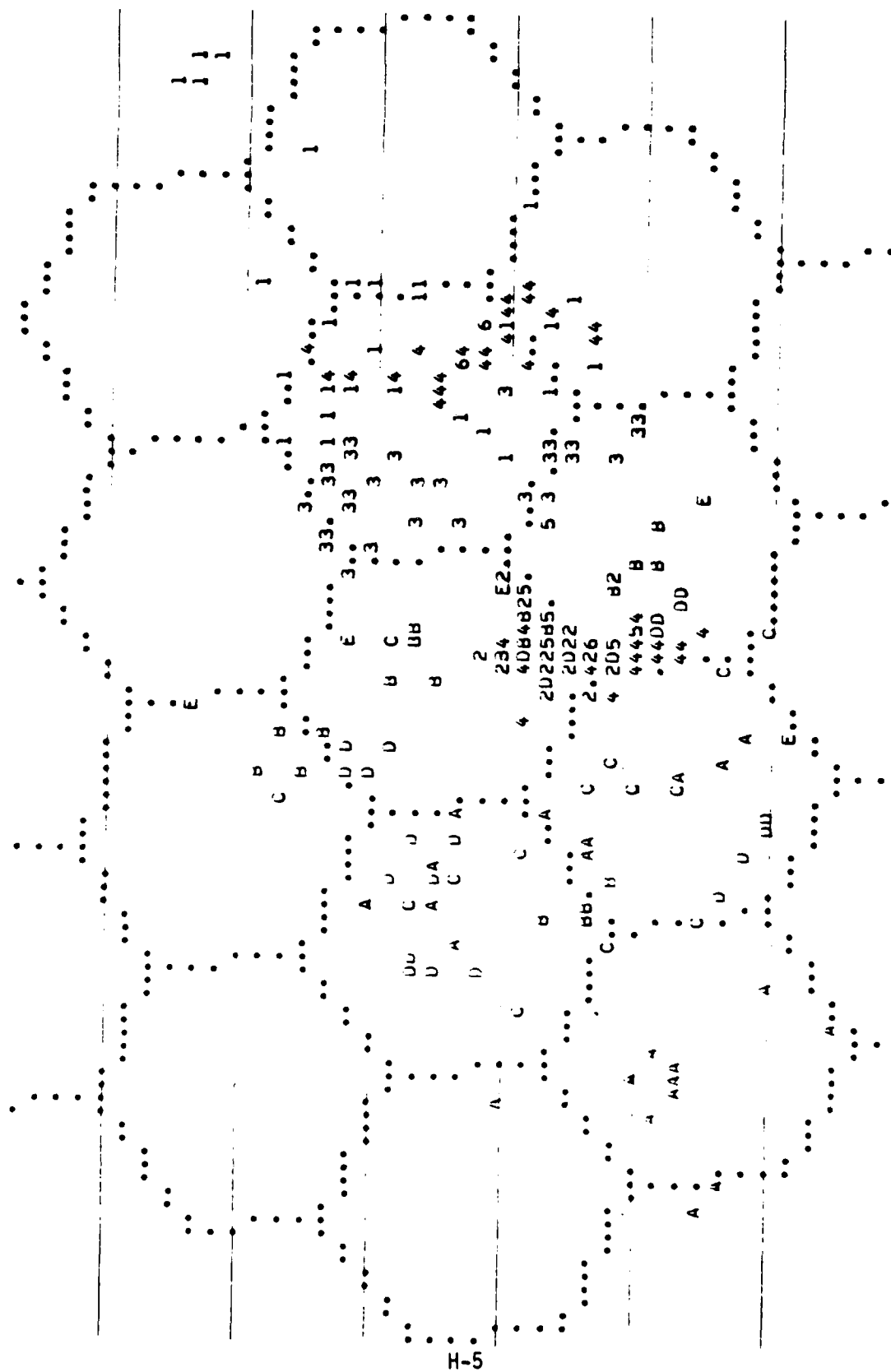


Figure H-4. Case III unit positions at 01:30 hours.

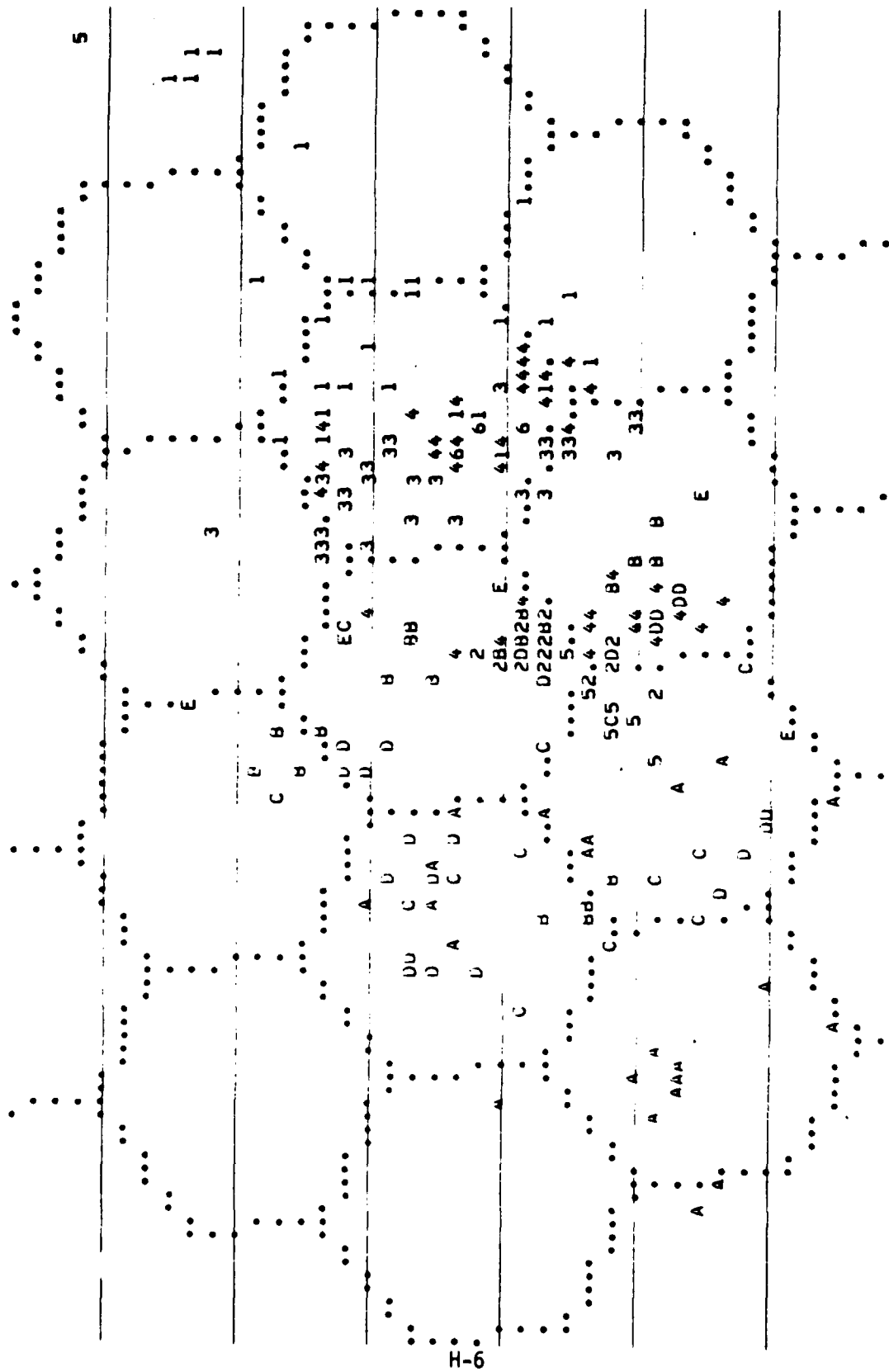


Figure H-5. Case III unit positions at 02:00 hours.

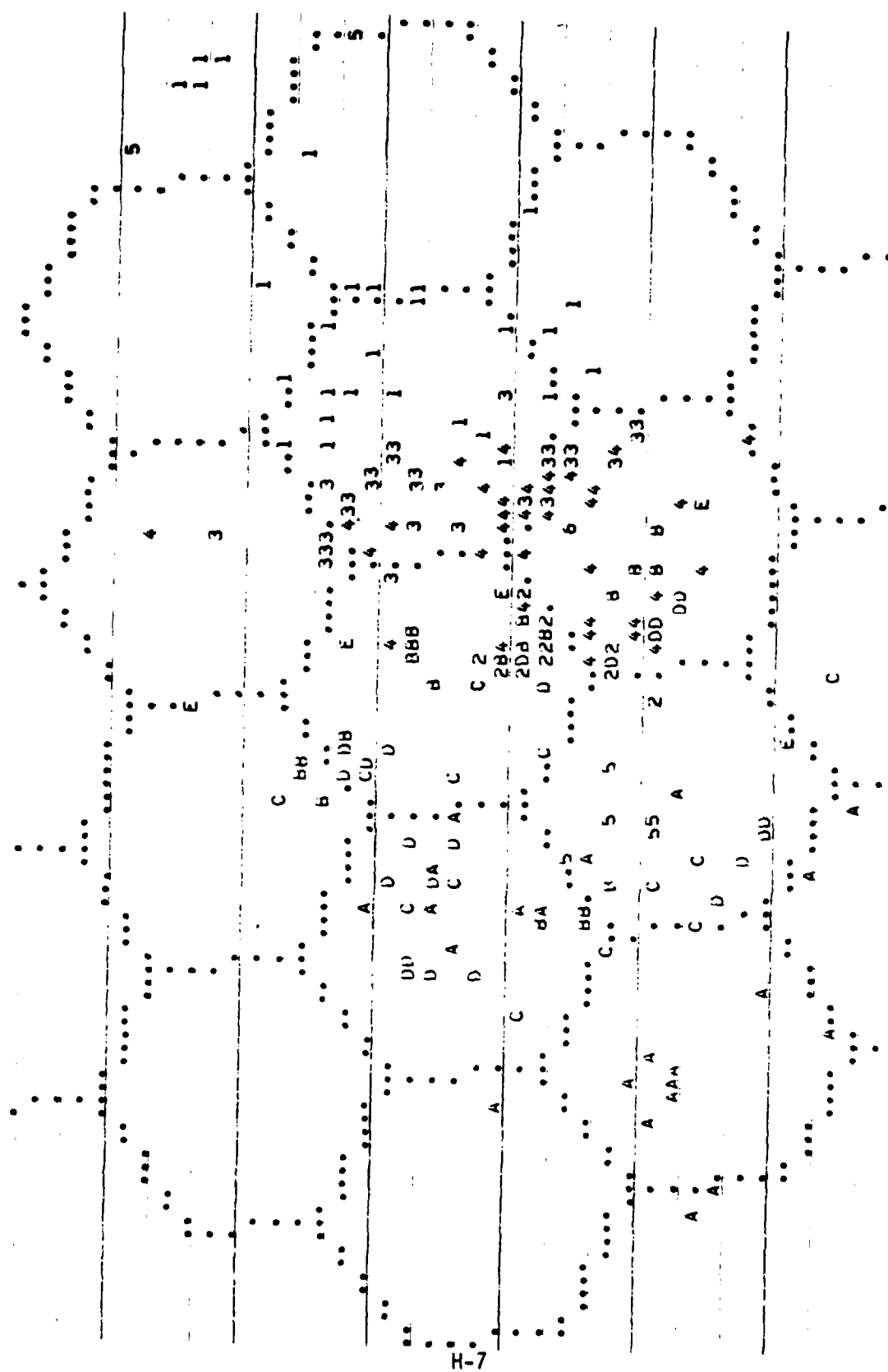
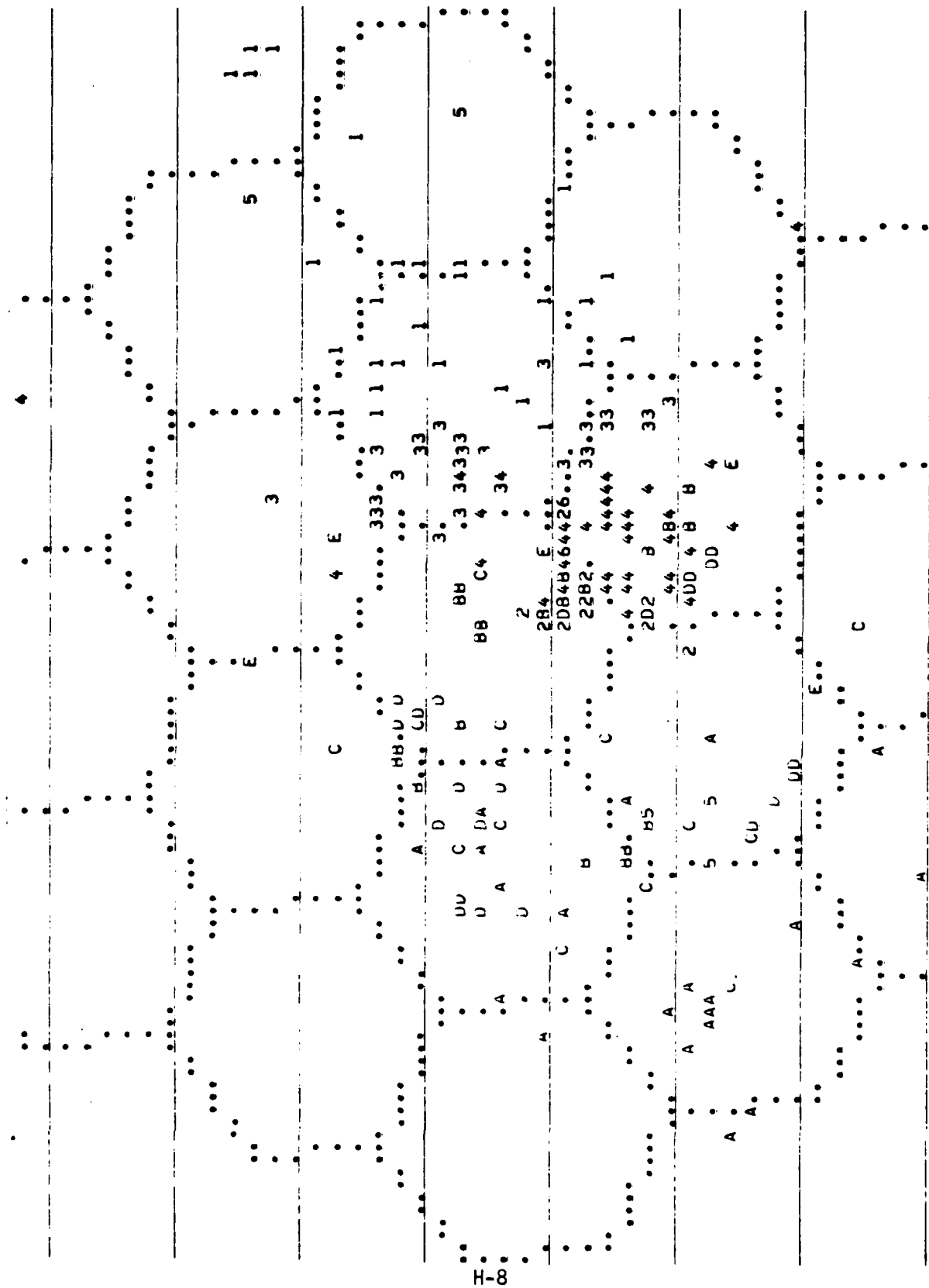


Figure H-6. Case III unit positions at 02:30 hours.





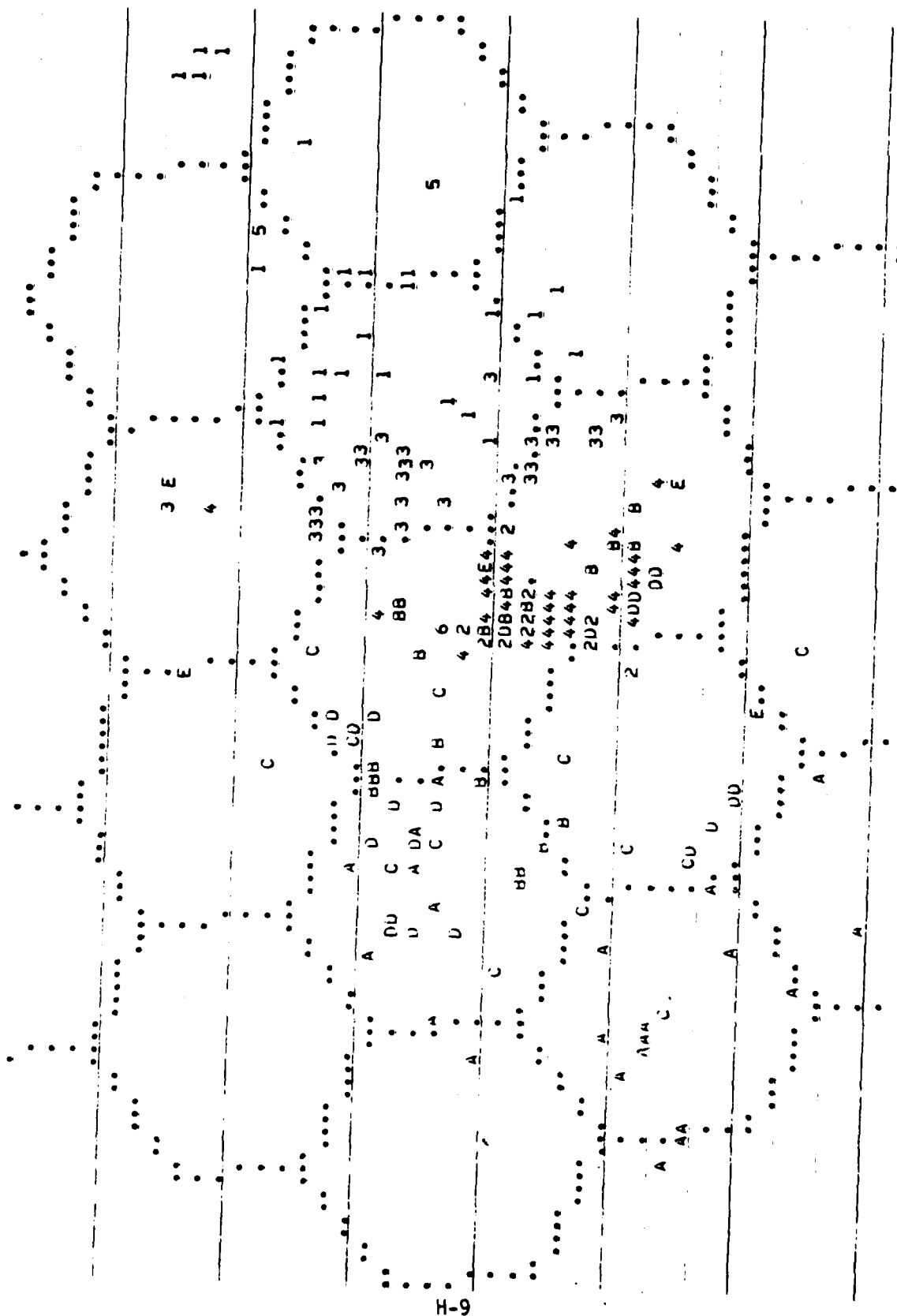


Figure H-8. Case III unit positions at 03:30 hours.

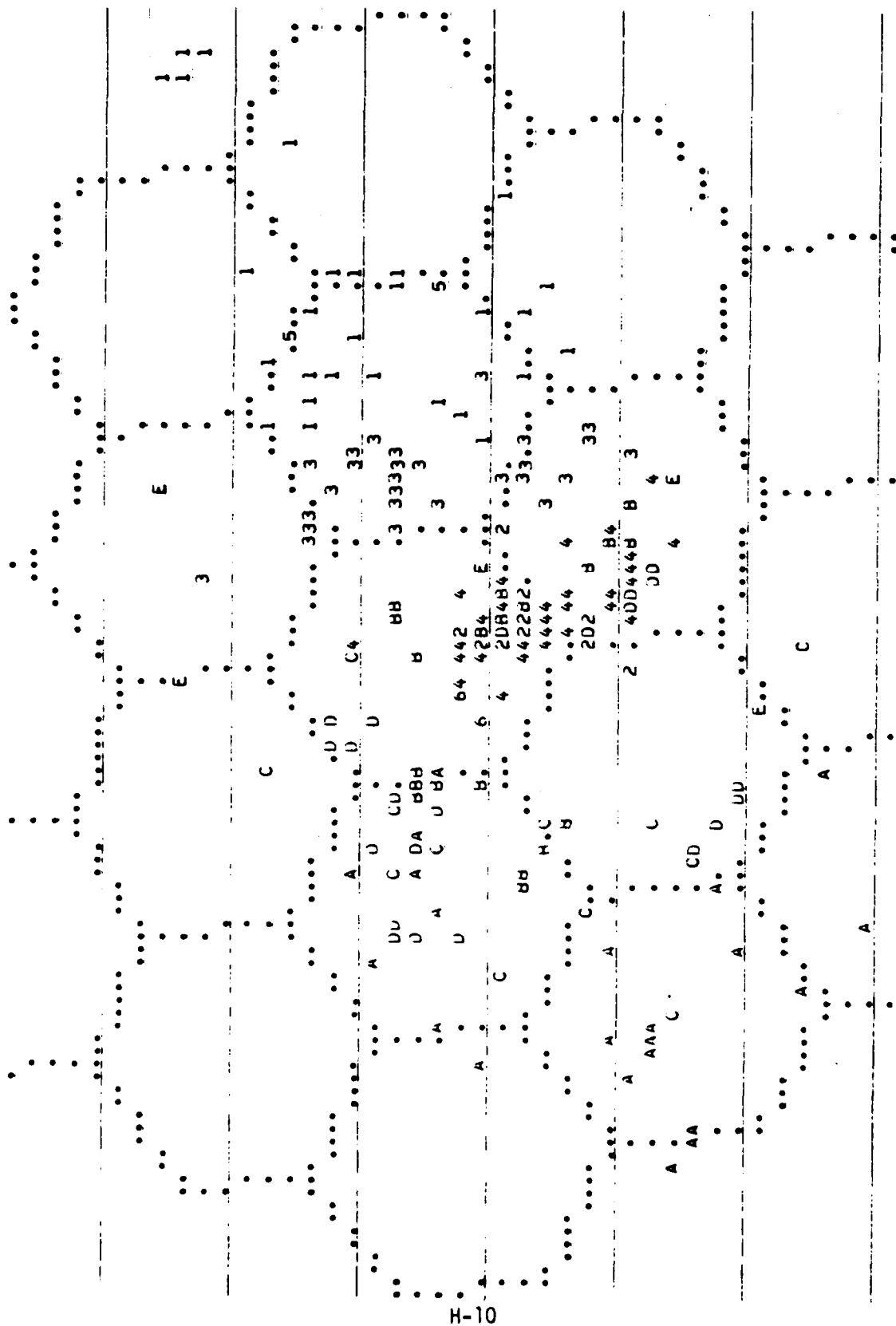


Figure H-9. Case III unit positions at 04:00 hours.

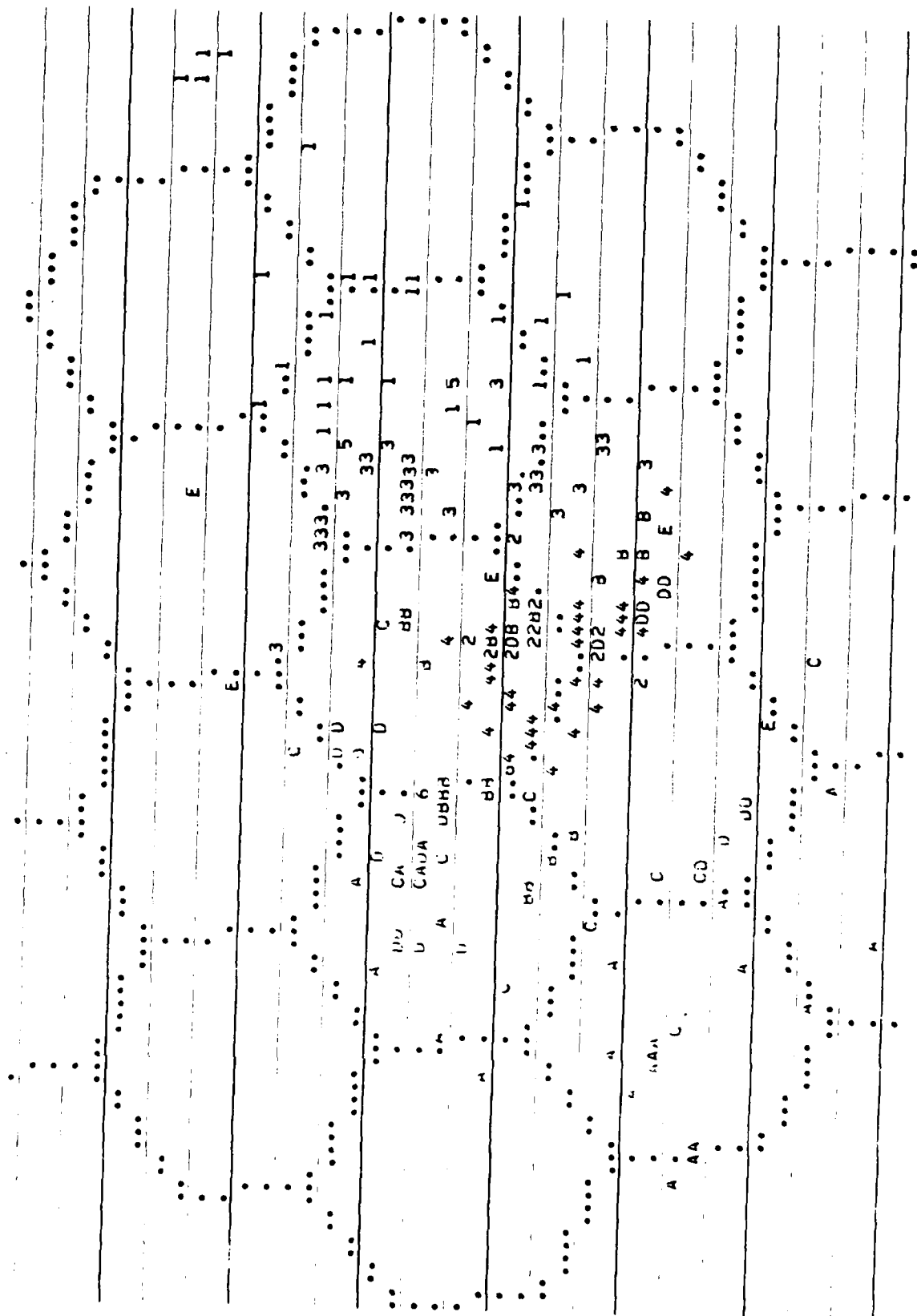


Figure H-10. Case III unit positions at 04:30 hours.

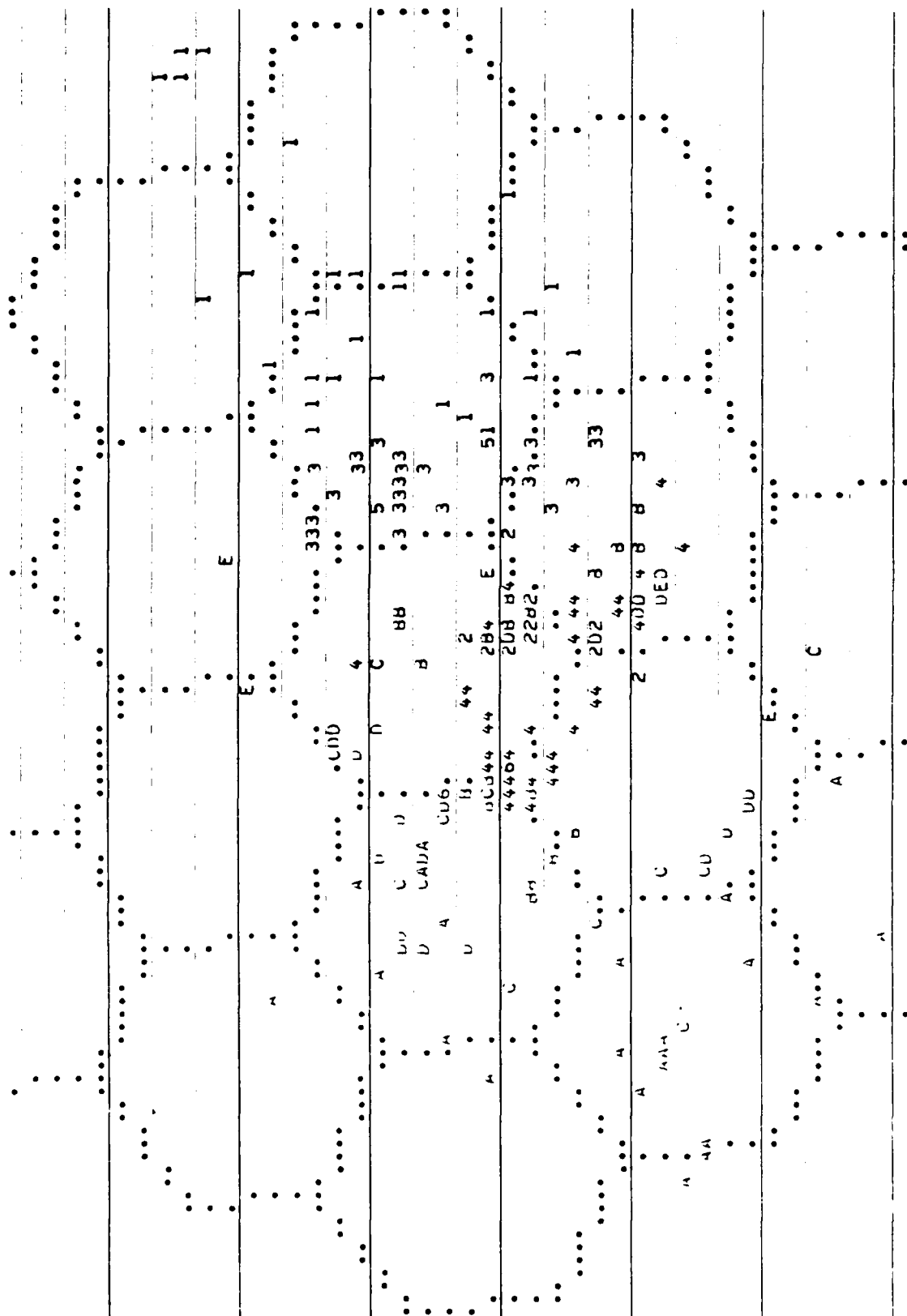
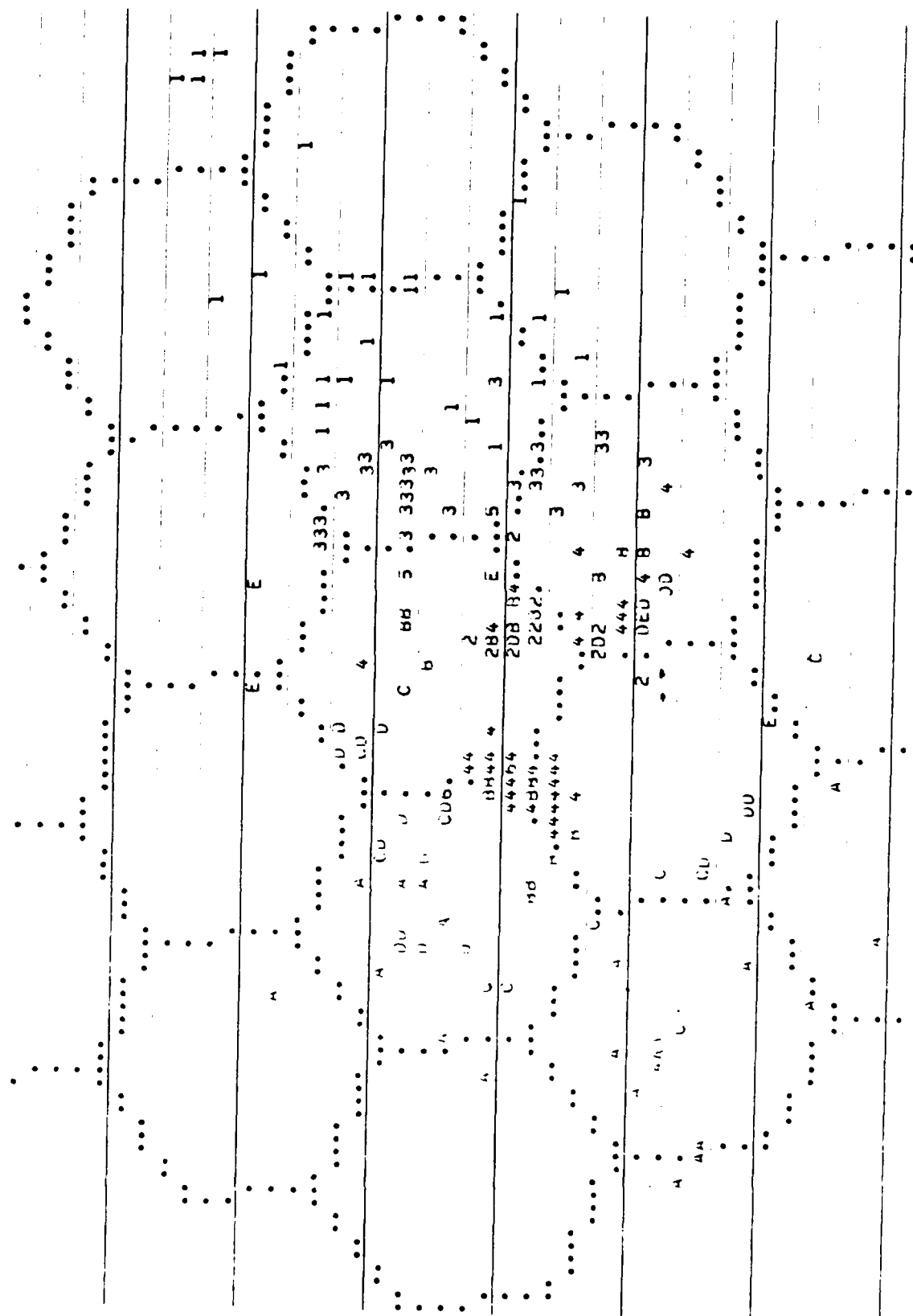


Figure H-11. Case III unit positions at 05:00 hours.



H-13

Figure H-12. Case III unit positions at 05:30 hours.

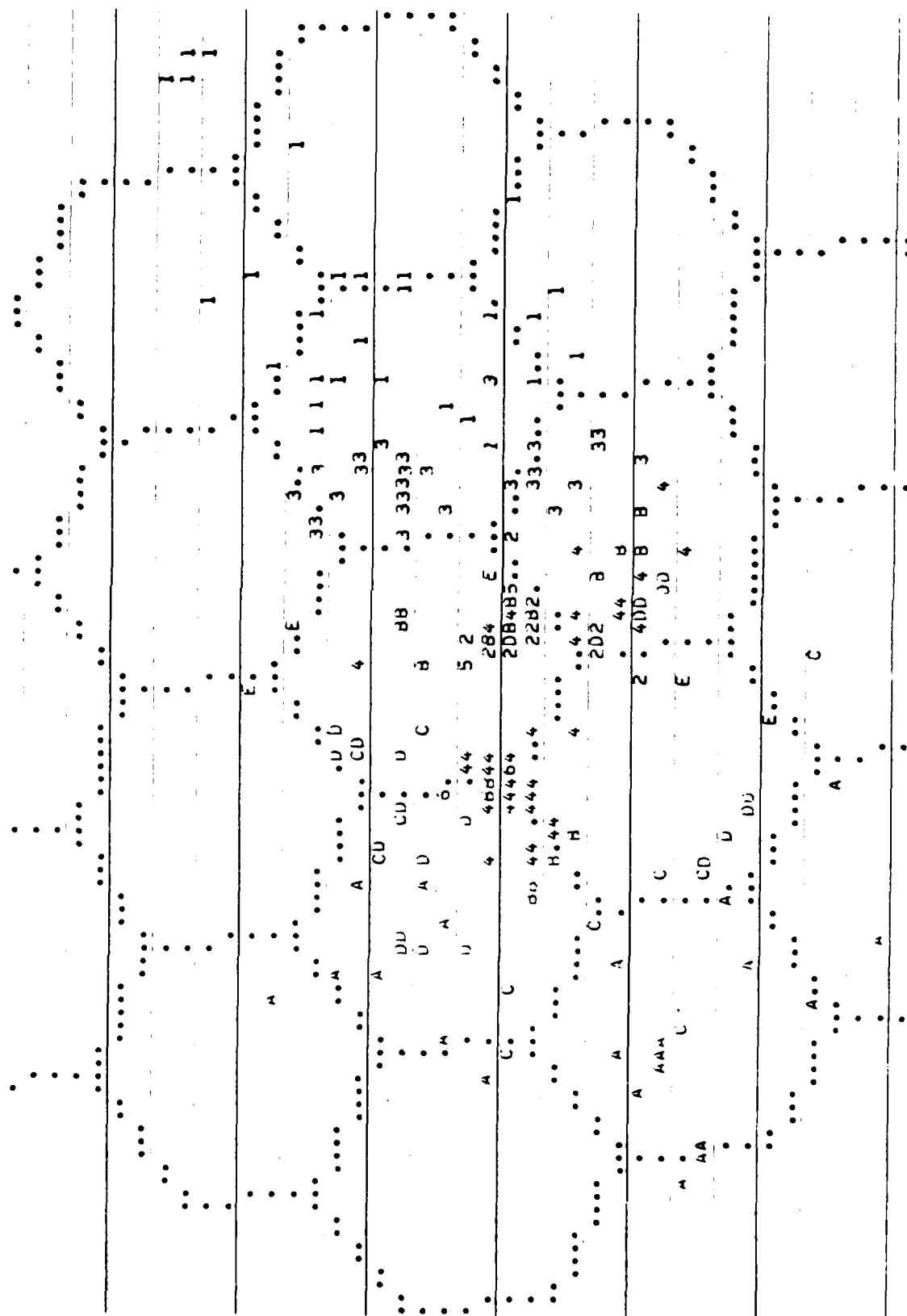


Figure H-13. Case III unit positions at 06:00 hours.

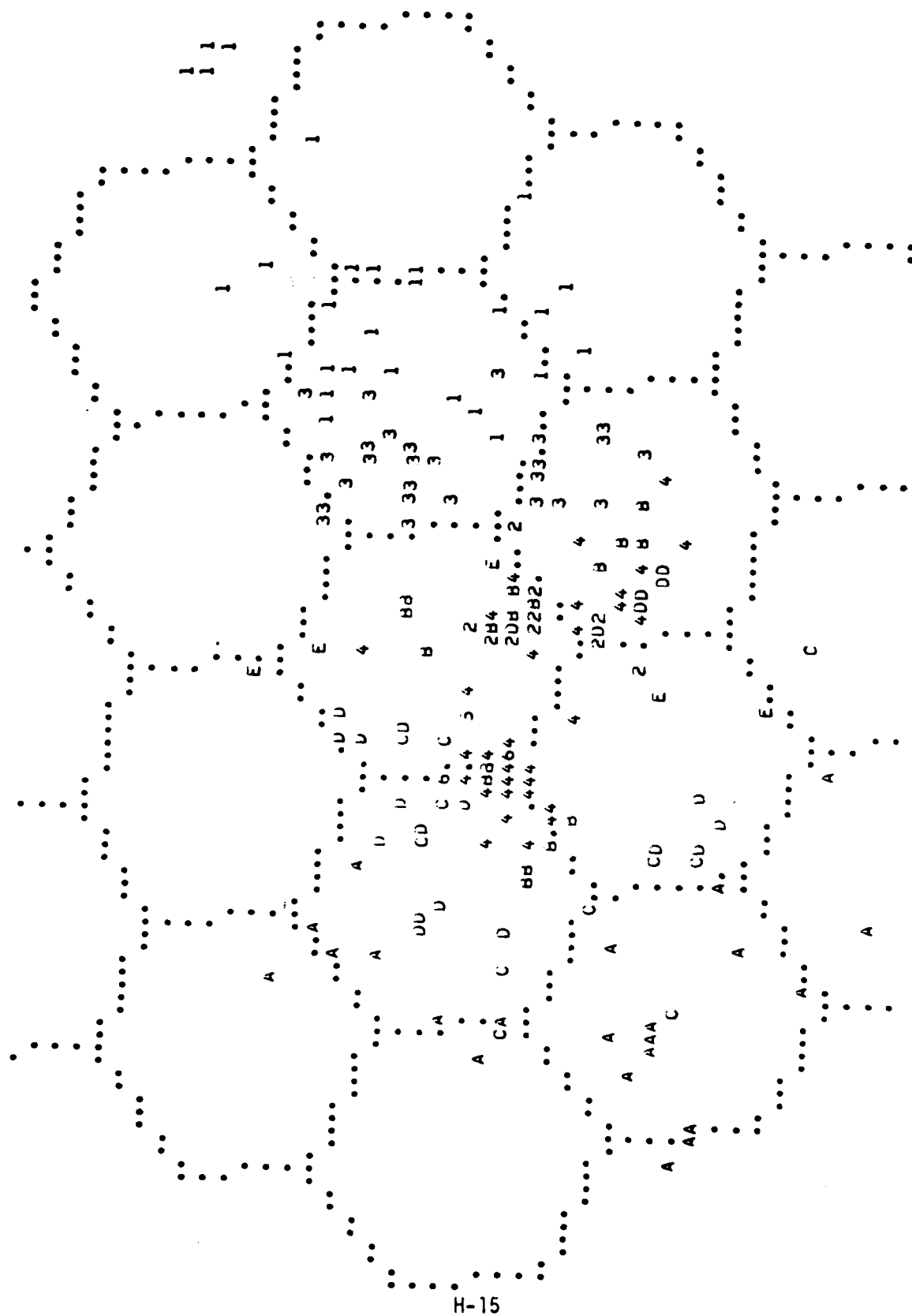


Figure H-14. Case III unit positions at 06:30 hours.

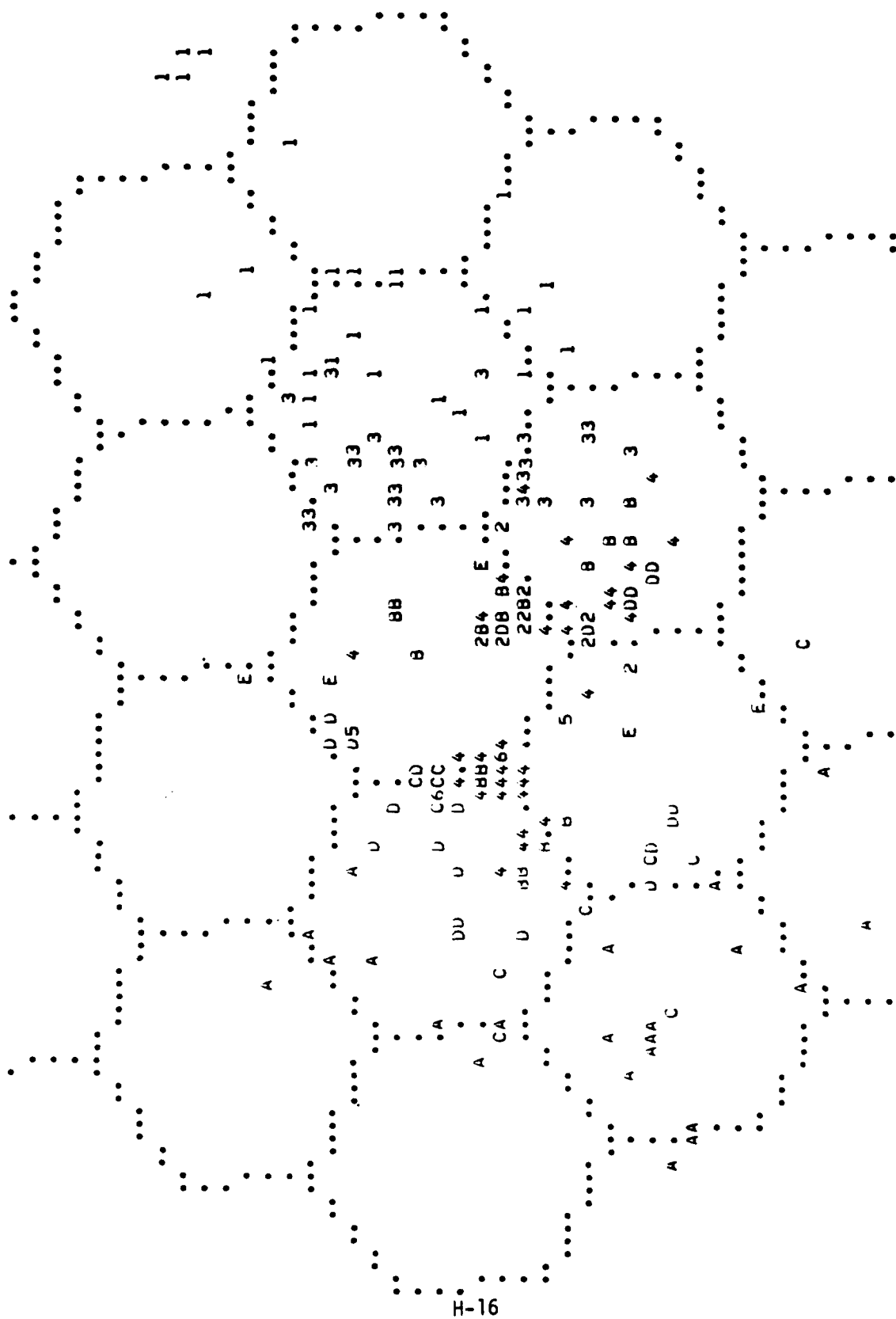


Figure H-15. Case III unit positions at 07:00 hours.



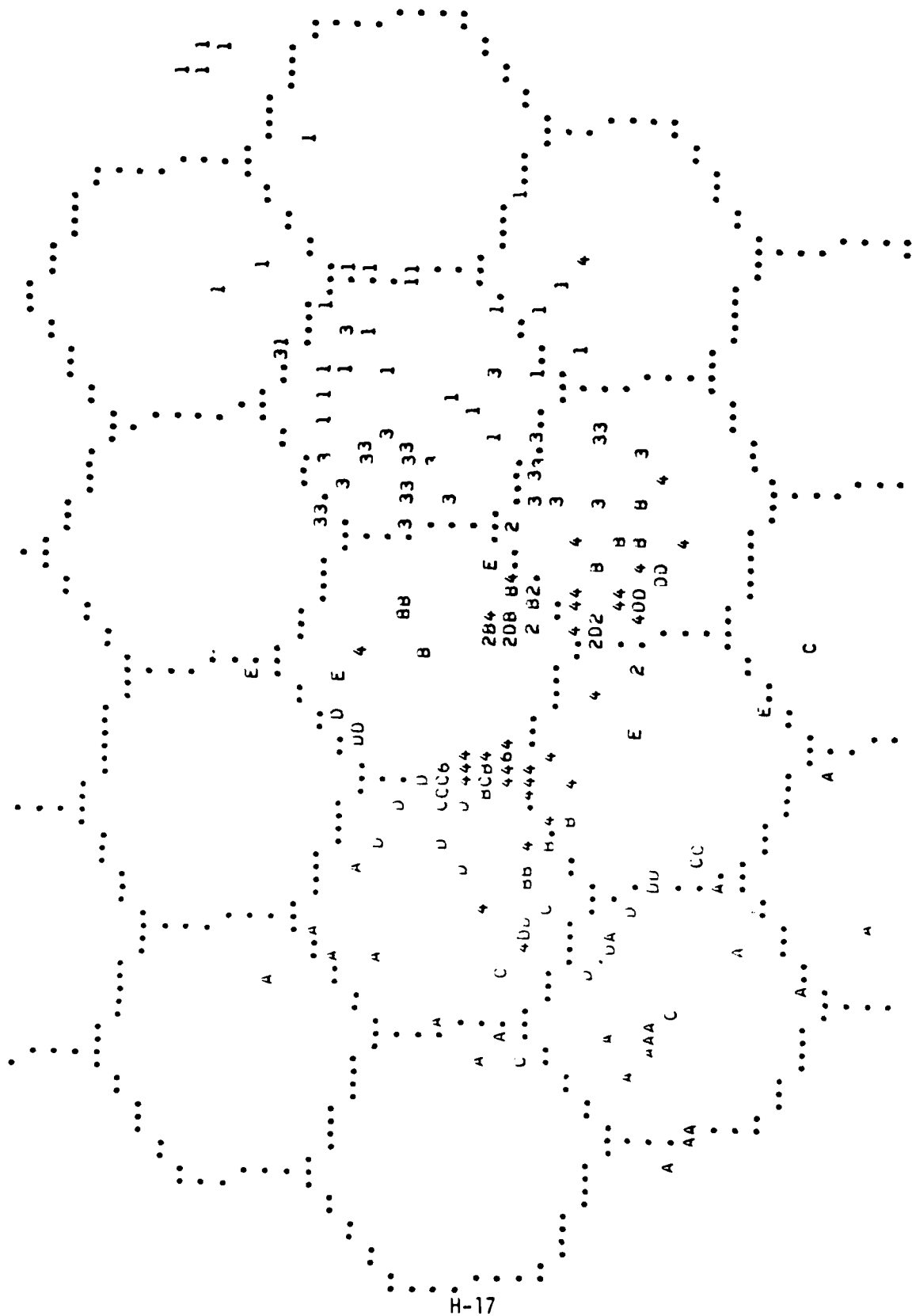


Figure H-16. Case III unit positions at 07:30 hours.

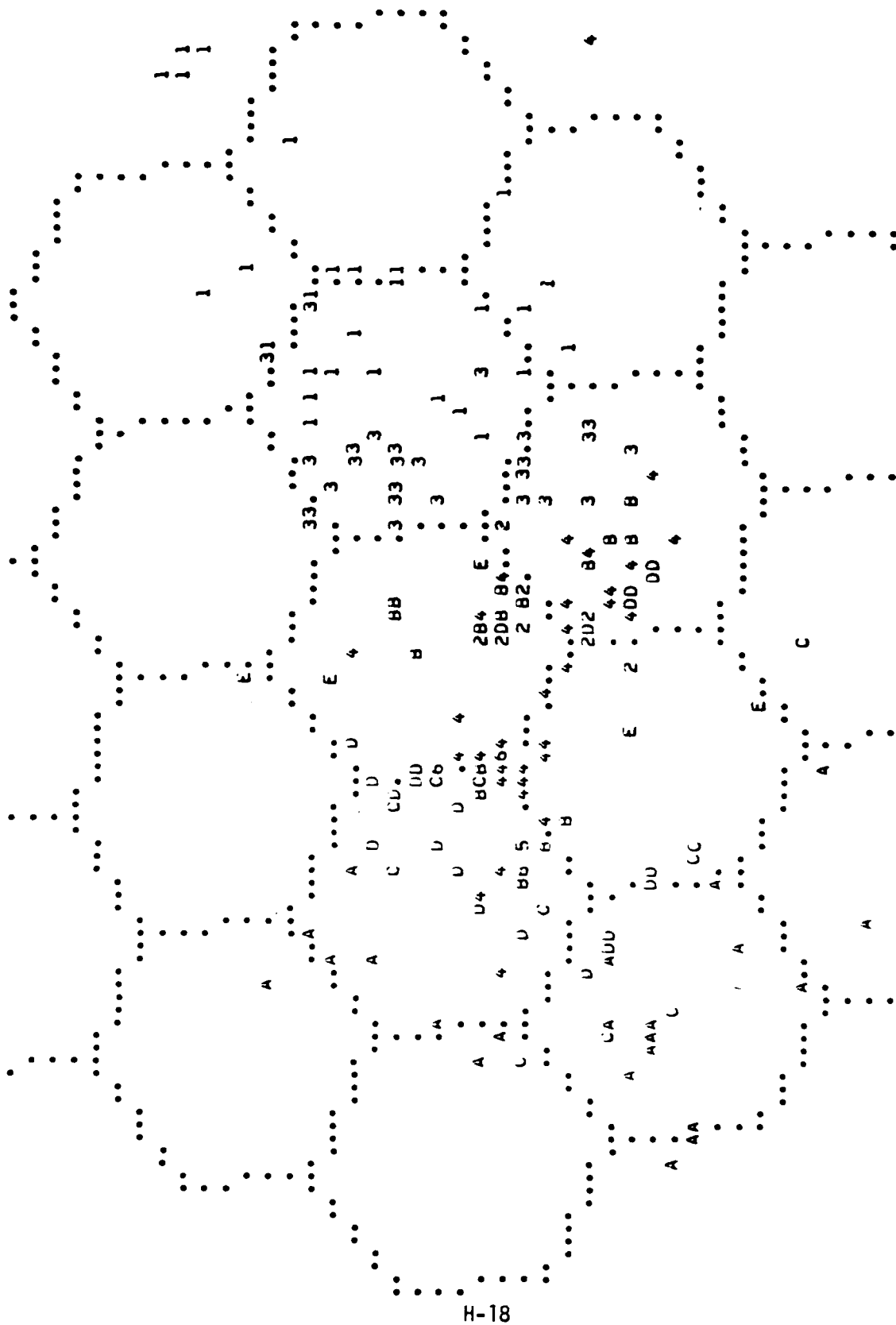


Figure H-17. Case III unit positions at 08:00 hours.

The quality of the original of this map  
was insufficient to be reproduced.

Figure H-18. Case III unit positions at 08:30 hours.

APPENDIX I  
CASE IV TACTICAL POSITION MAPS

The 18 maps presented in this appendix show the dynamic combat positions of both combatants at the company/battery level from zero to 0830 hours in one-half hour increments. Legend and other pertinent information concerning these maps is the same as for Case I, Appendix F.

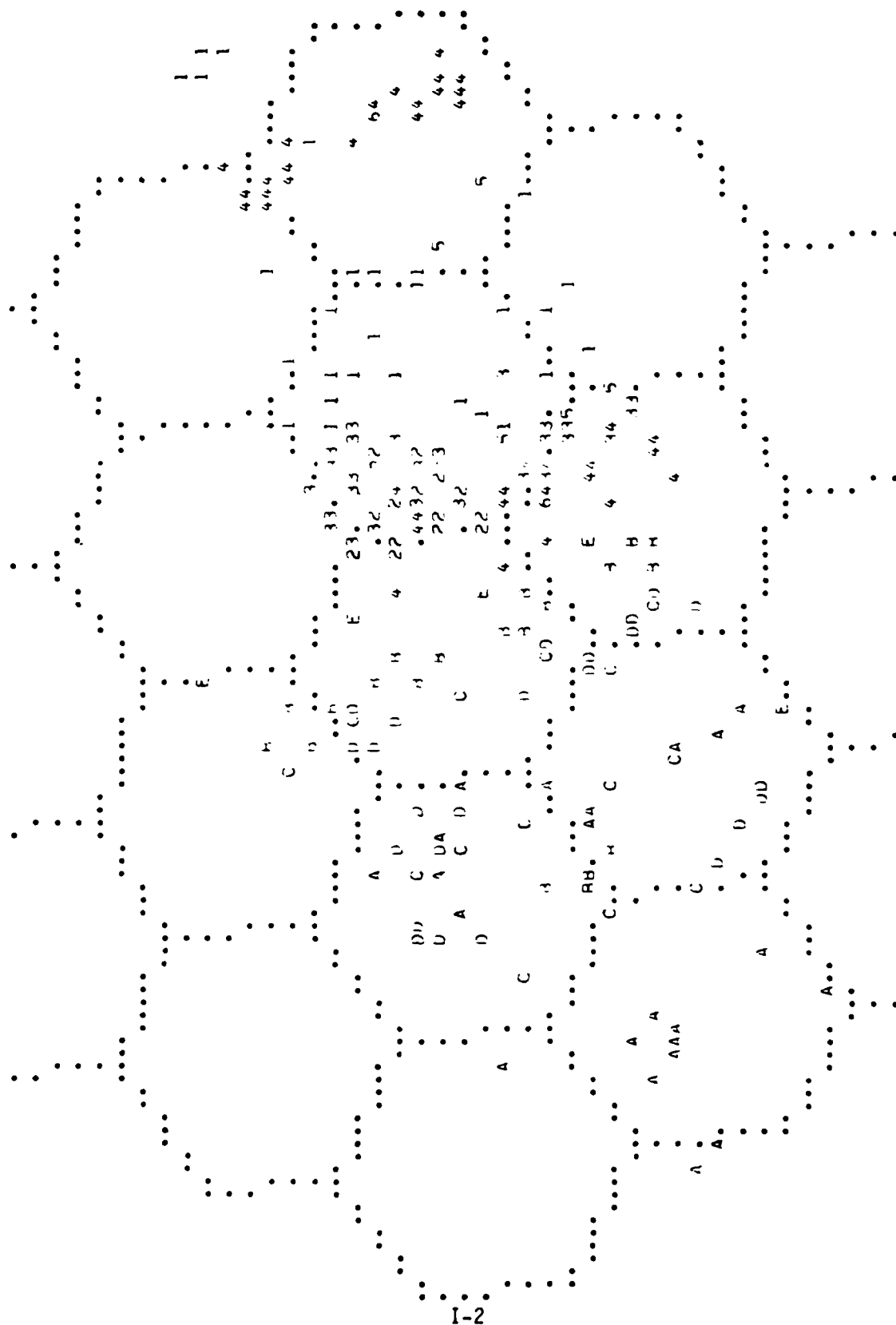


Figure I-1. Case IV unit positions at 00:00 hours.

The quality of the original of this map  
was insufficient to be reproduced.

Figure I-2. Case IV unit positions at 00:30 hours.

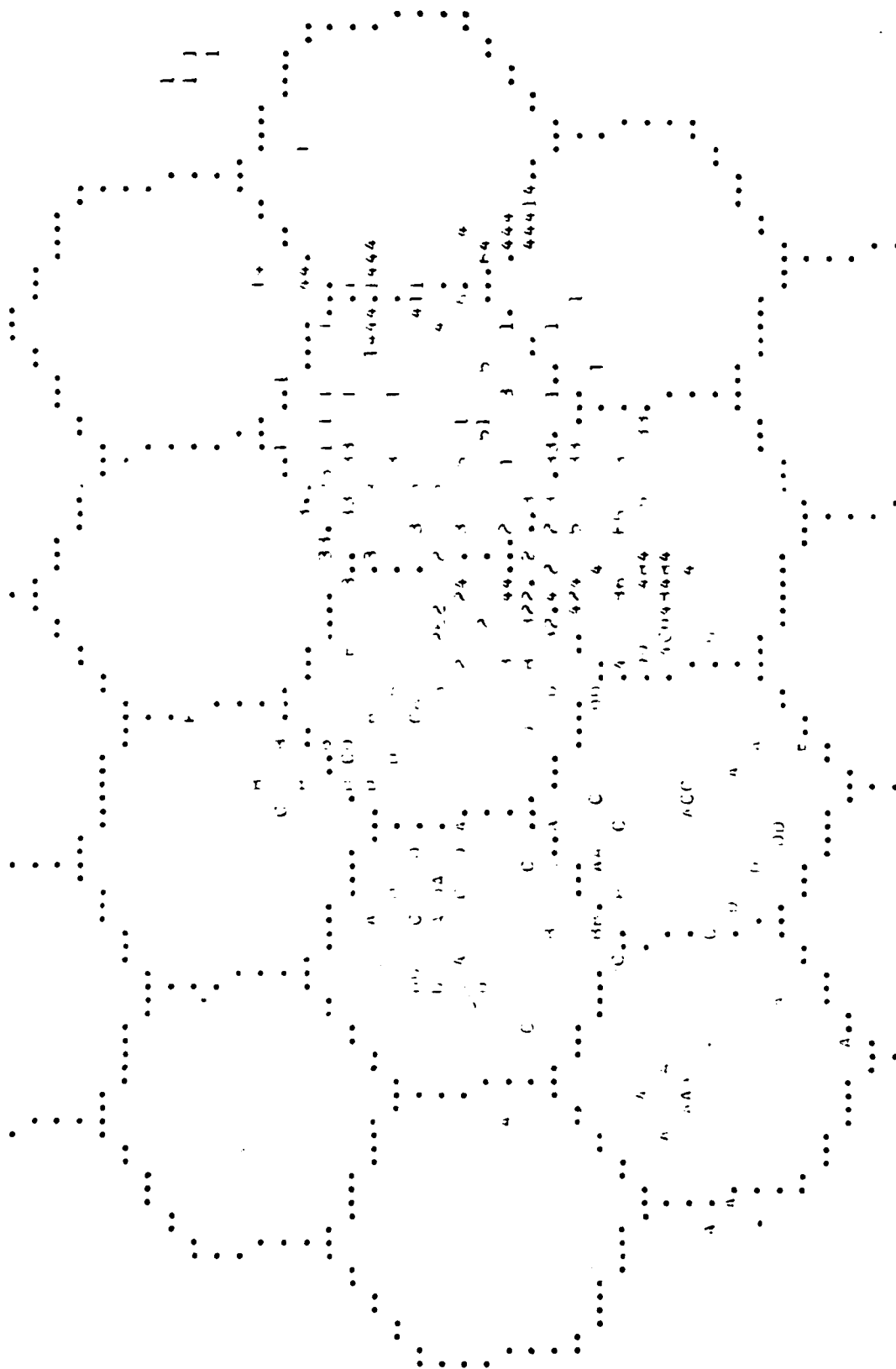


Figure I-3. Case IV unit positions at 01:00 hours.

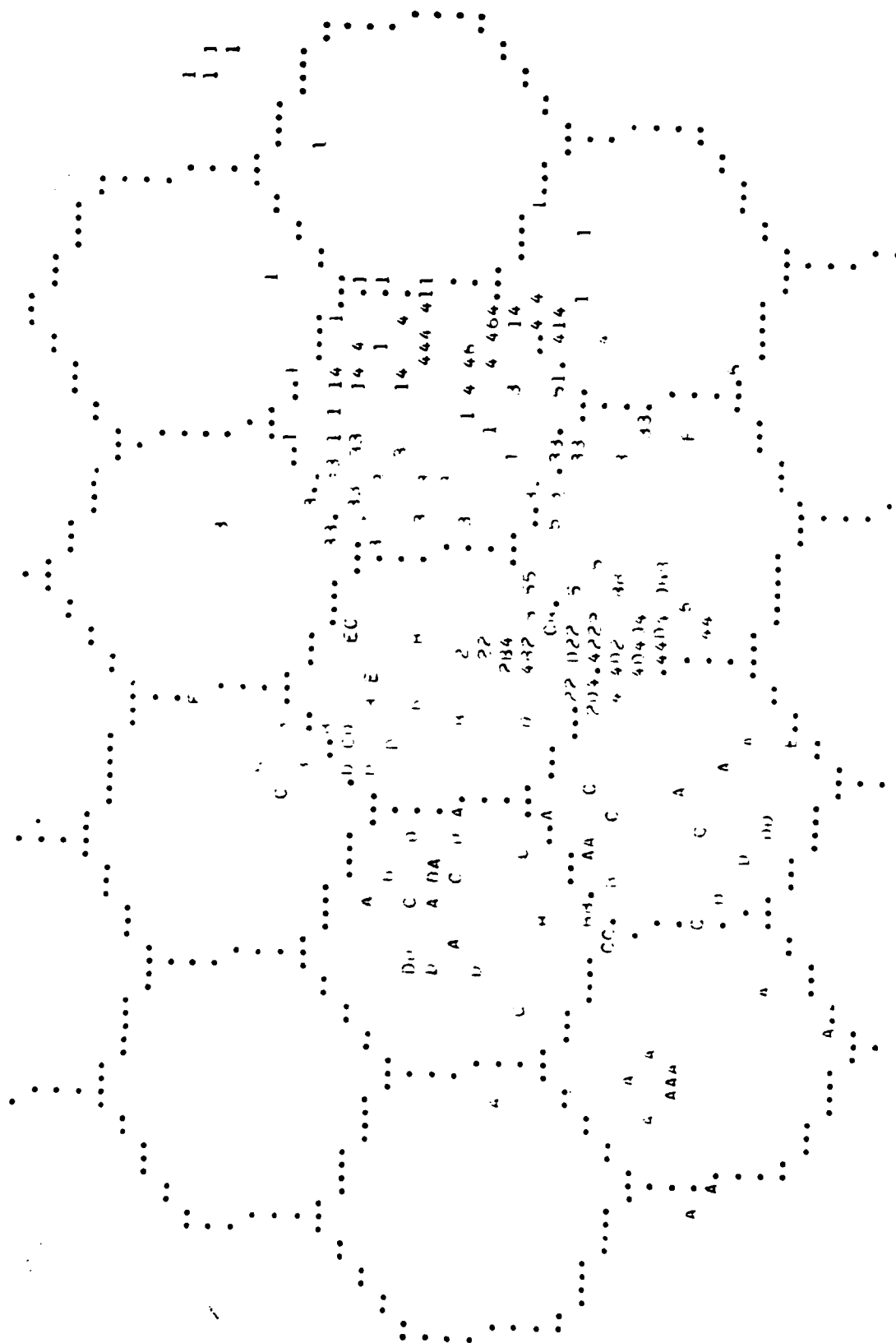
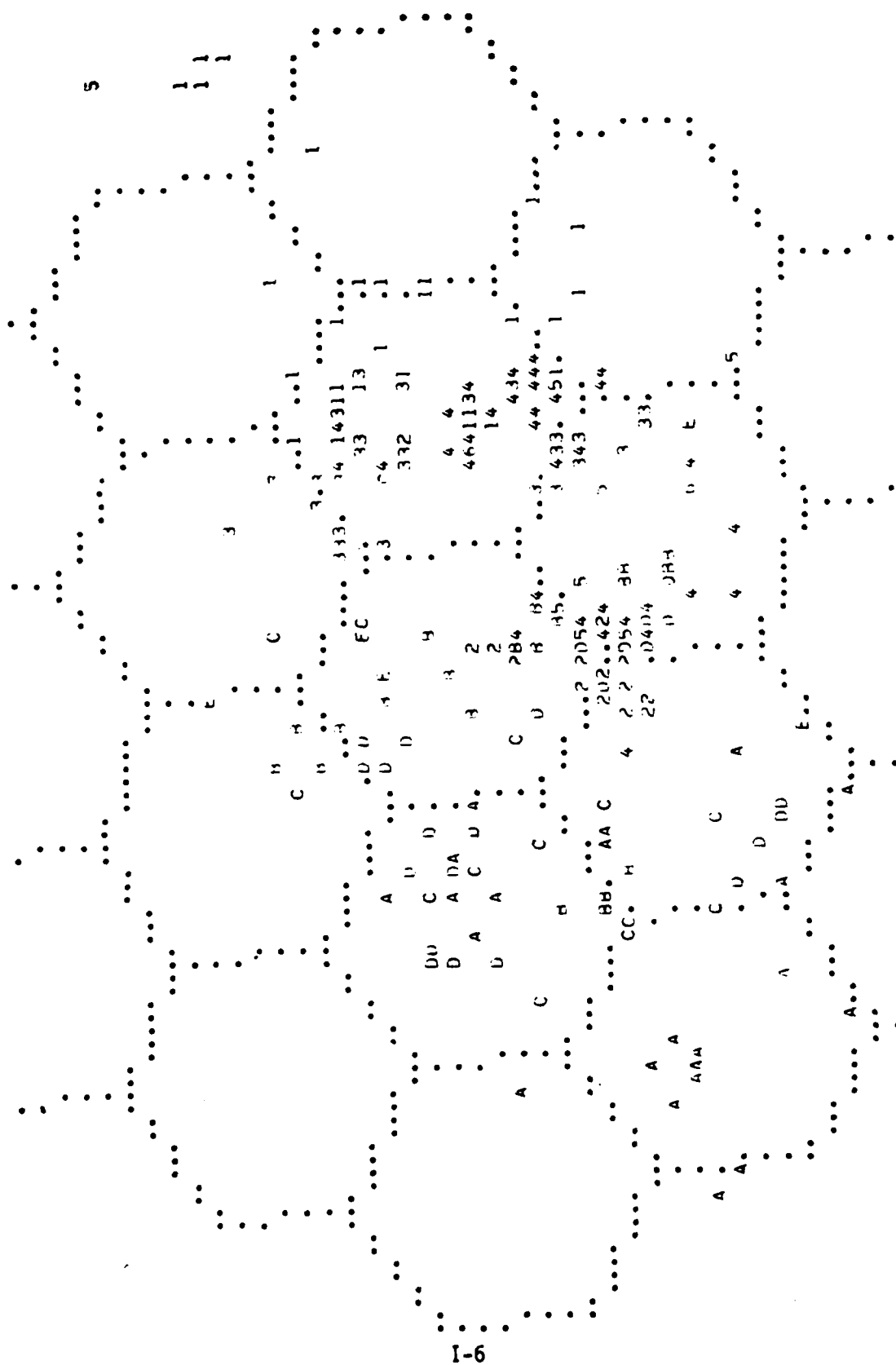
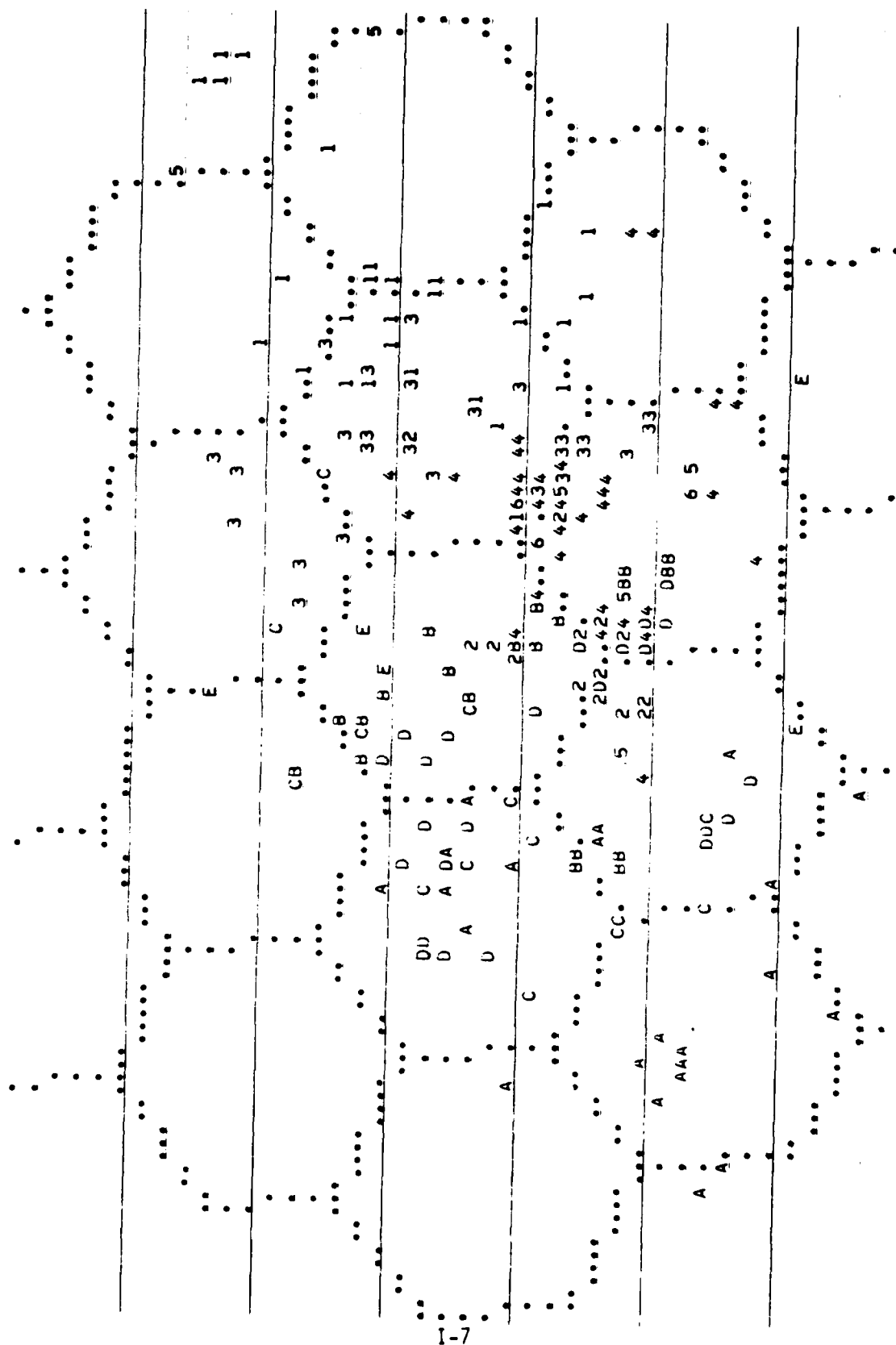


Figure I-4. Case IV unit positions at 01:30 hours.







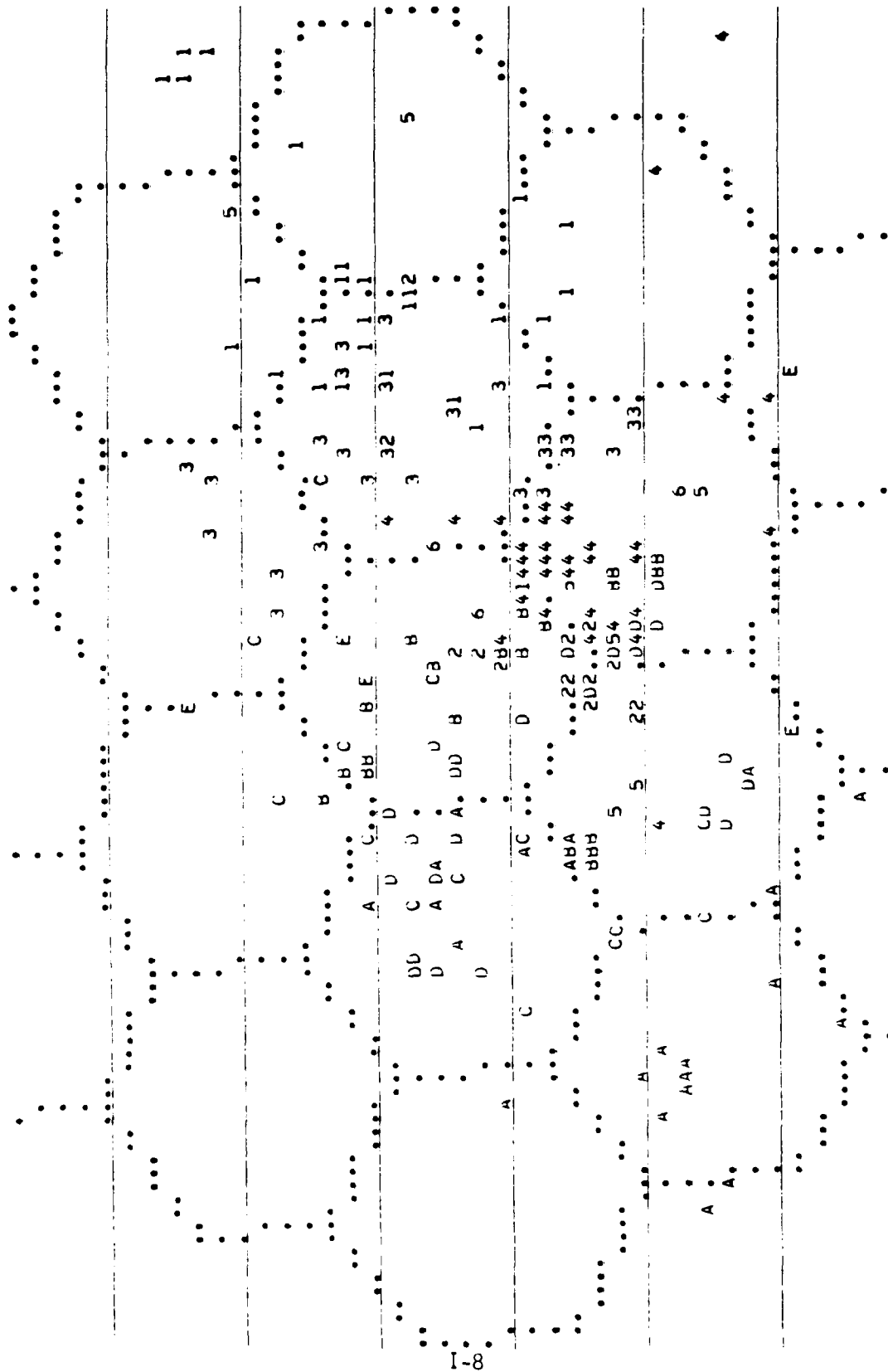


Figure I-7. Case IV unit positions at 03:00 hours.

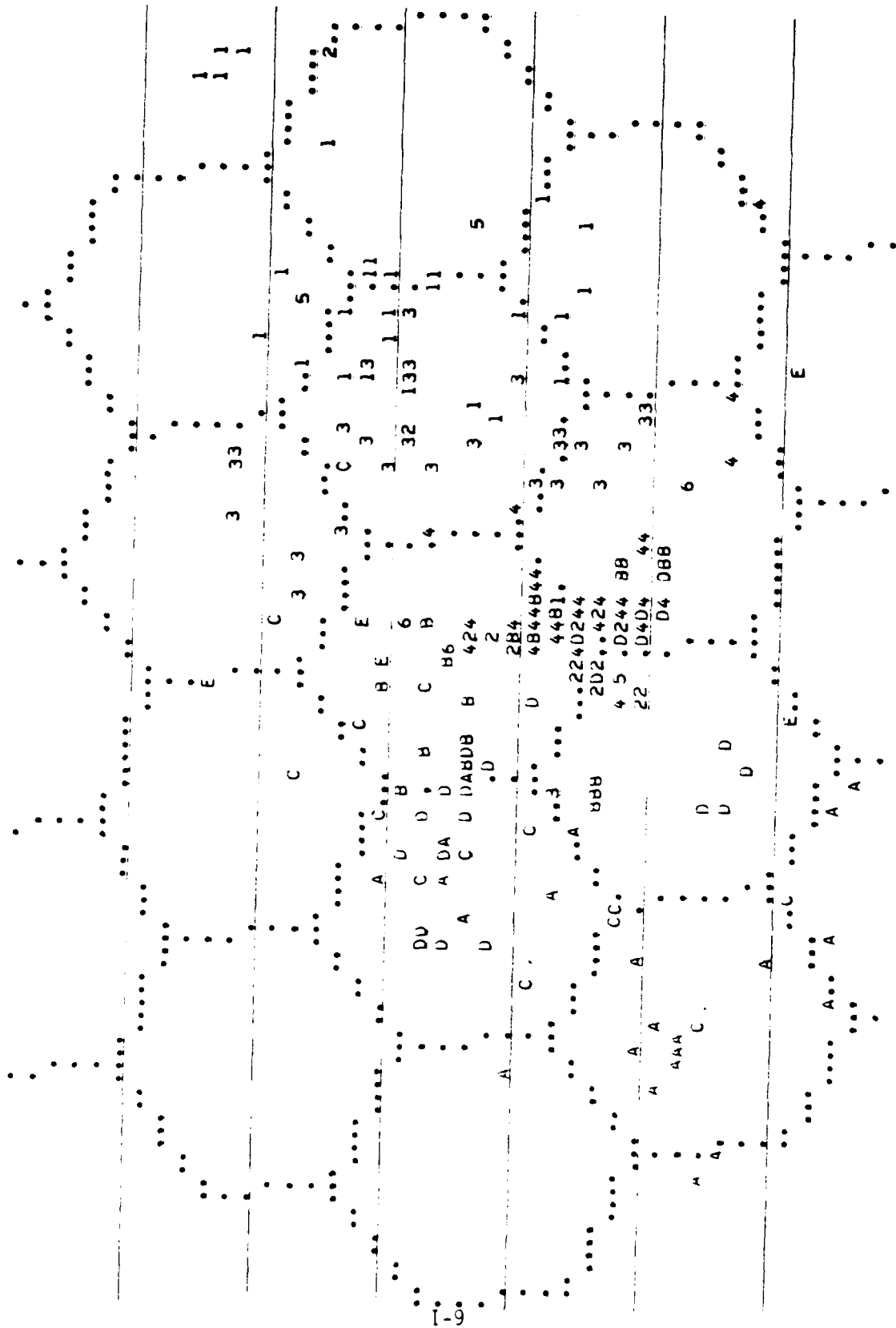
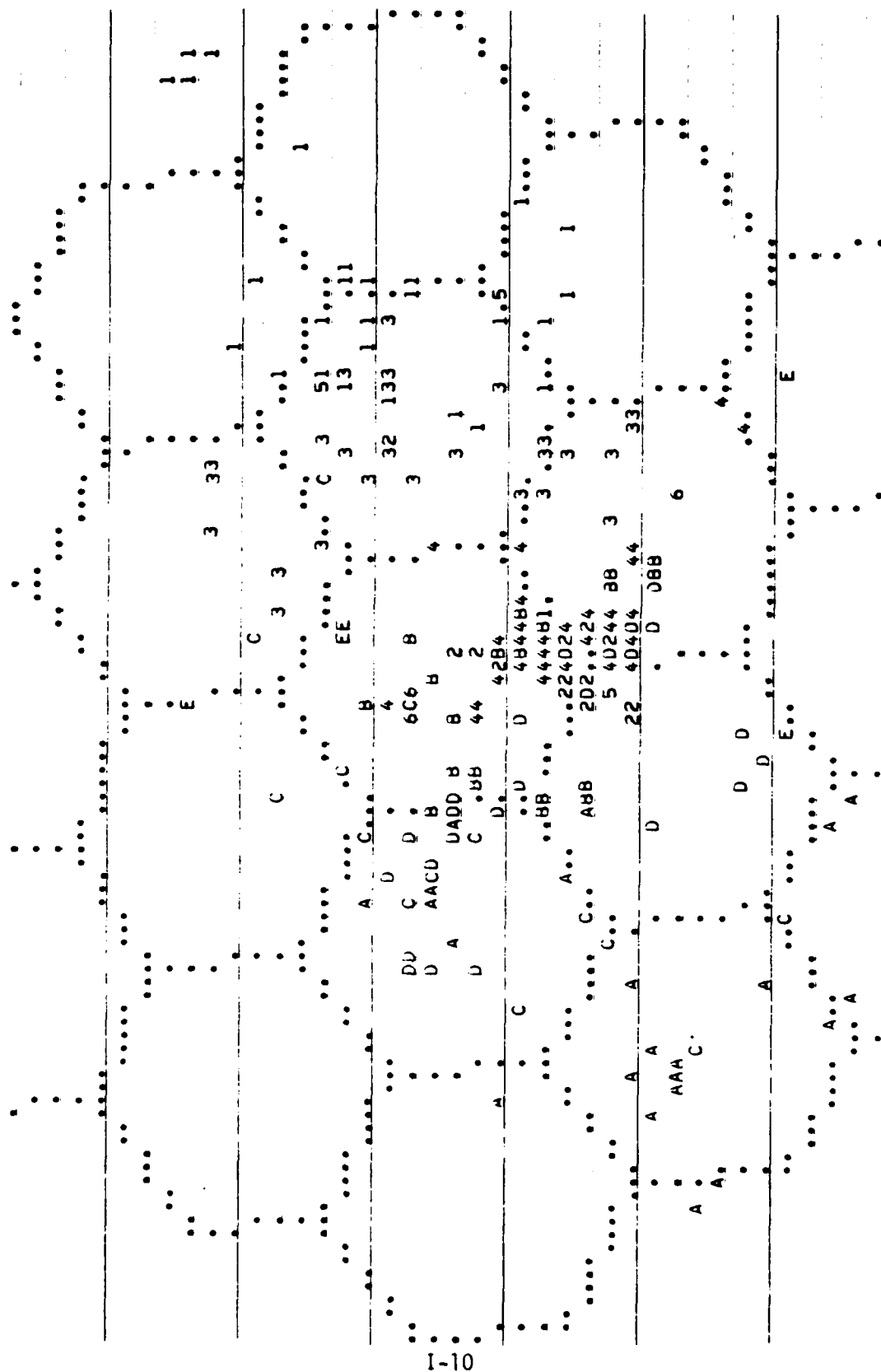


Figure I-8. Case IV unit positions at 03:30 hours.



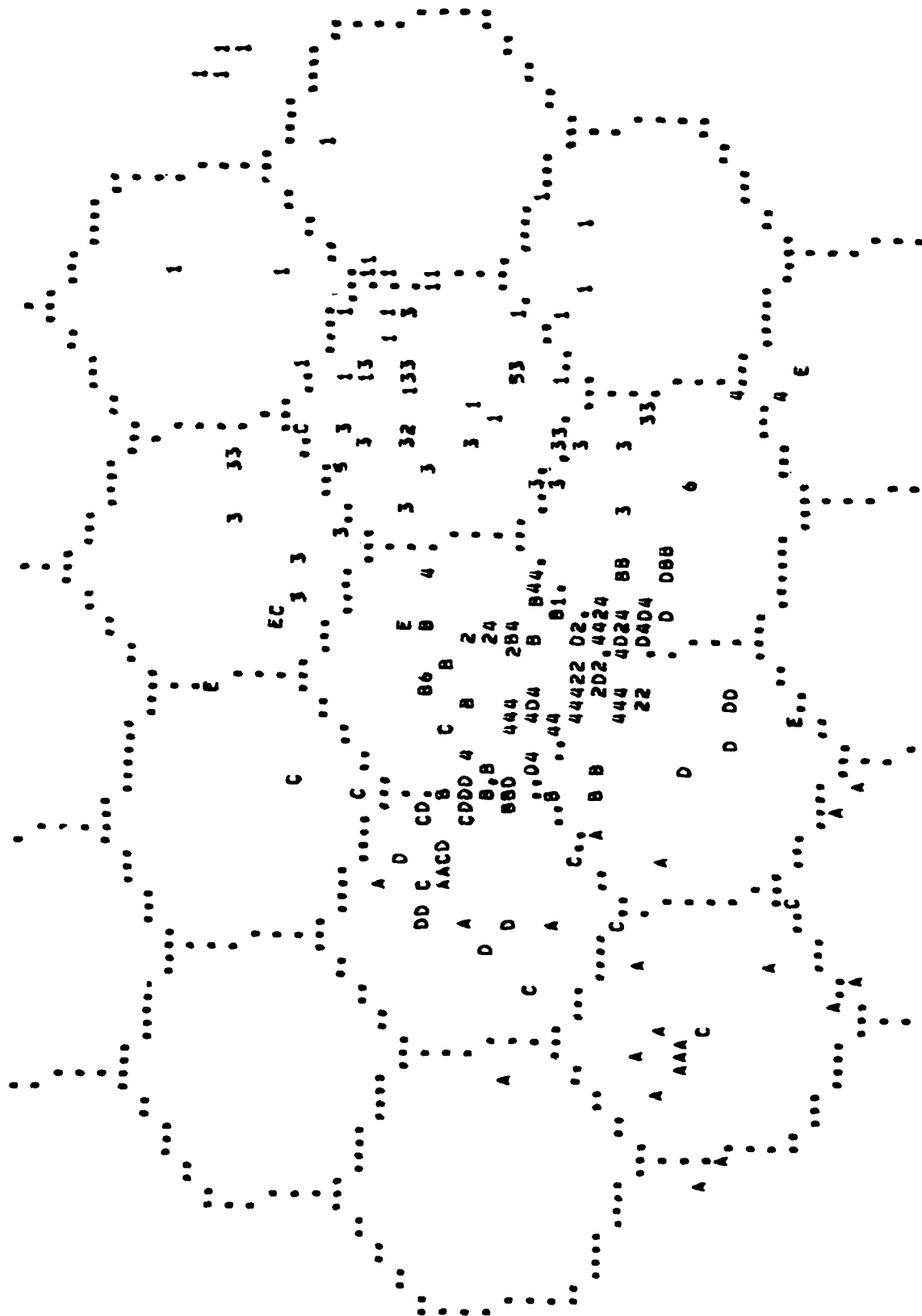


Figure I-10. Case IV unit positions at 04:30 hours.

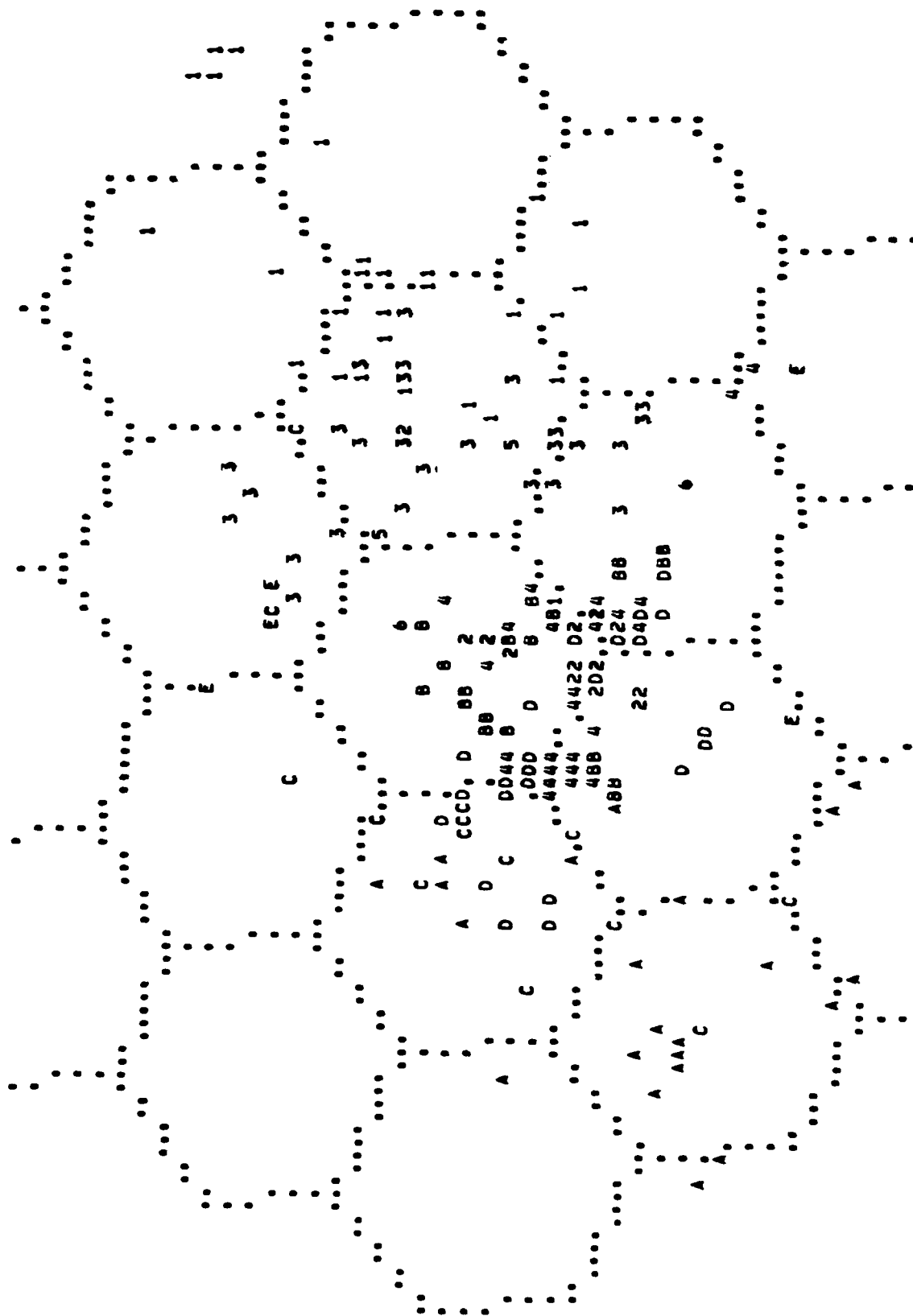
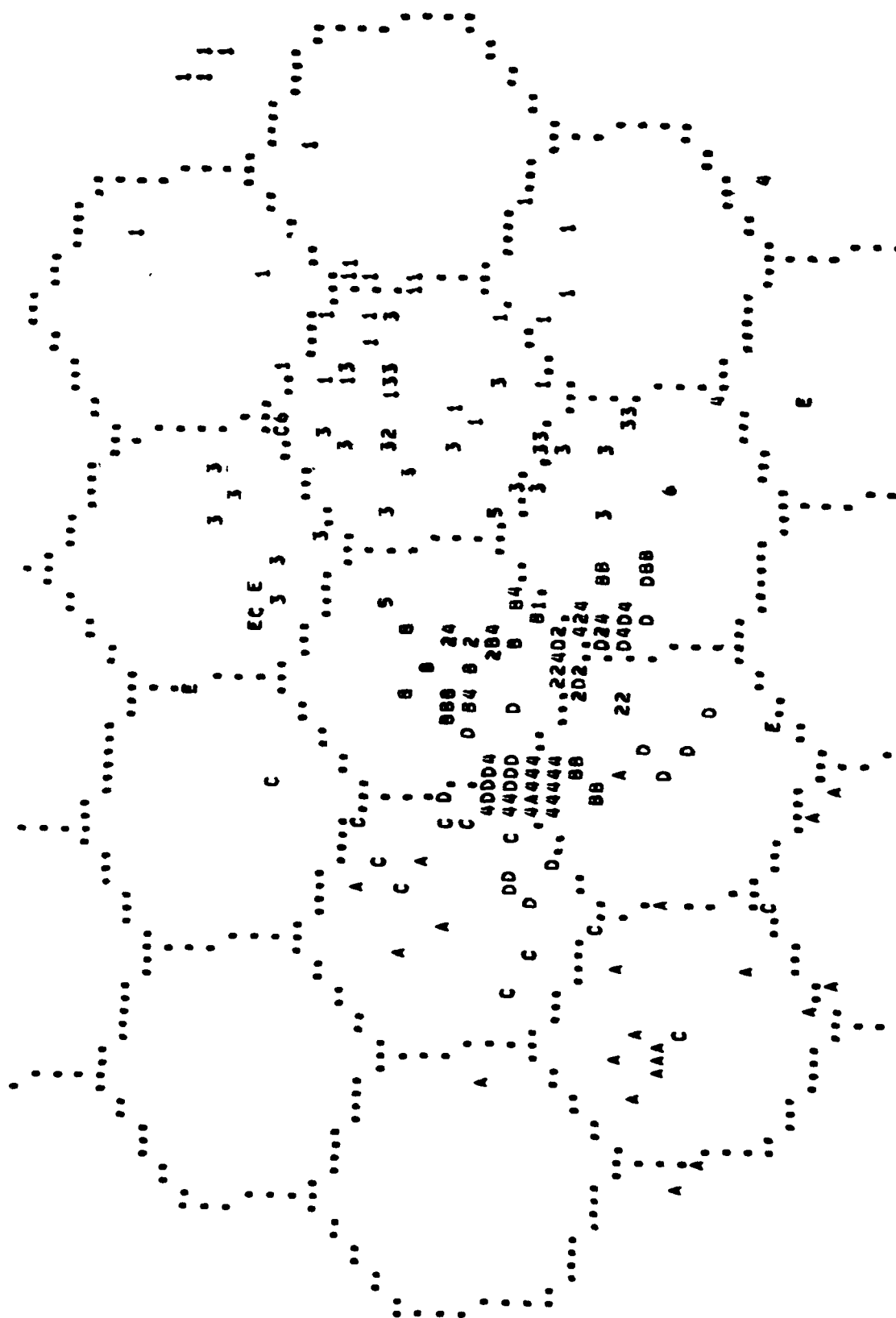
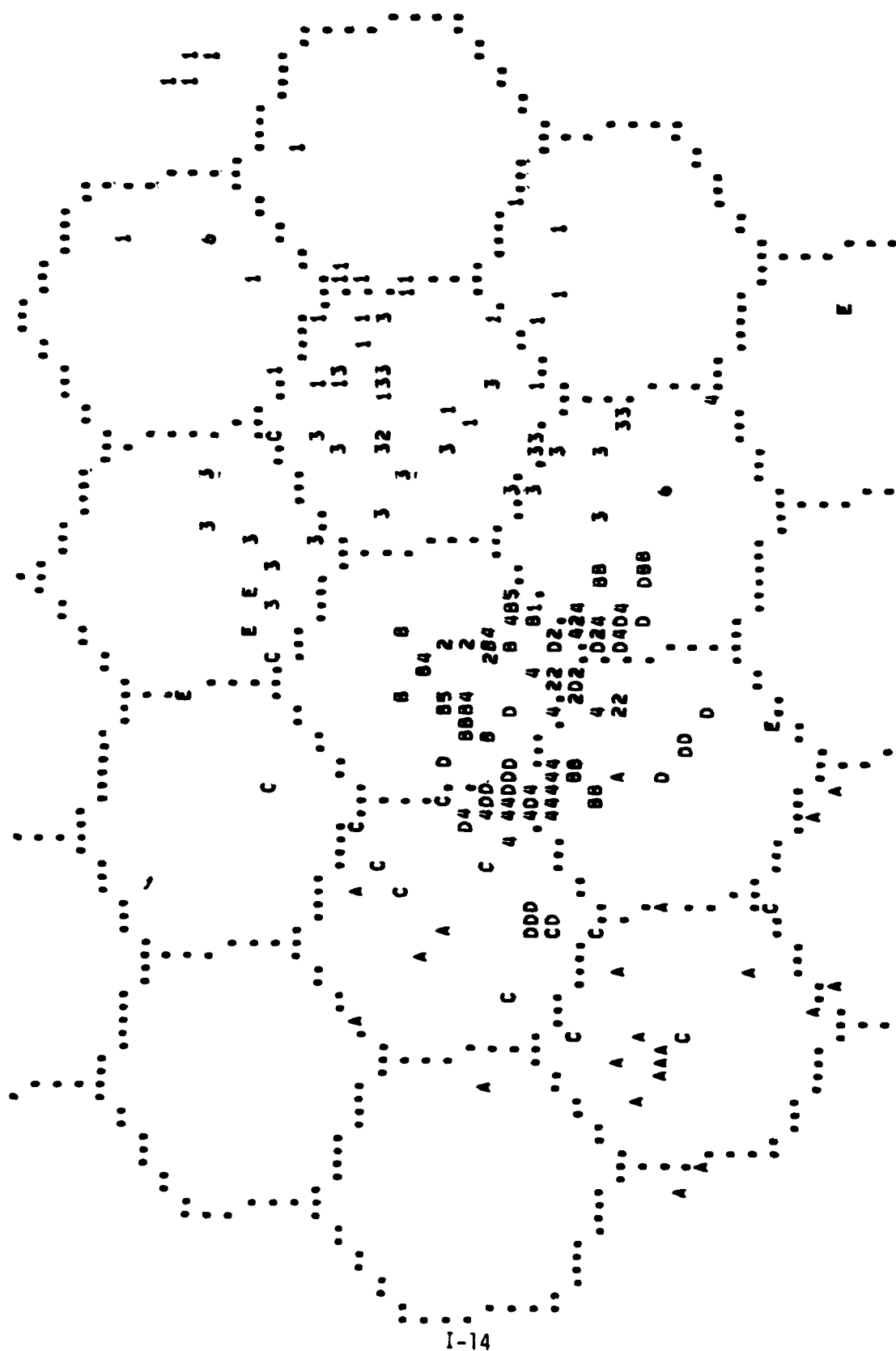
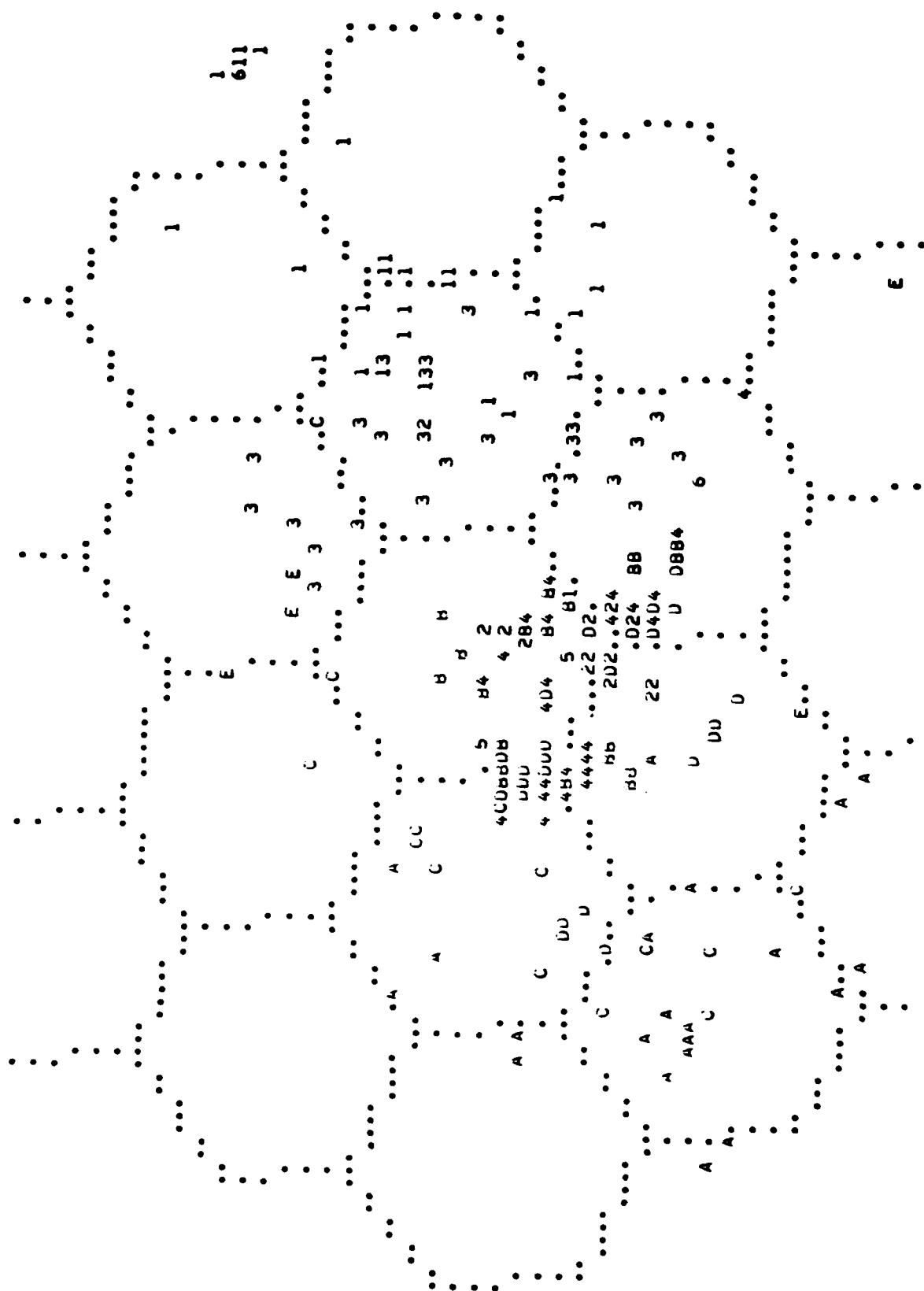


Figure I-11. Case IV unit positions at 05:00 hours.









**Figure I-14. Case IV unit positions at 06:30 hours.**

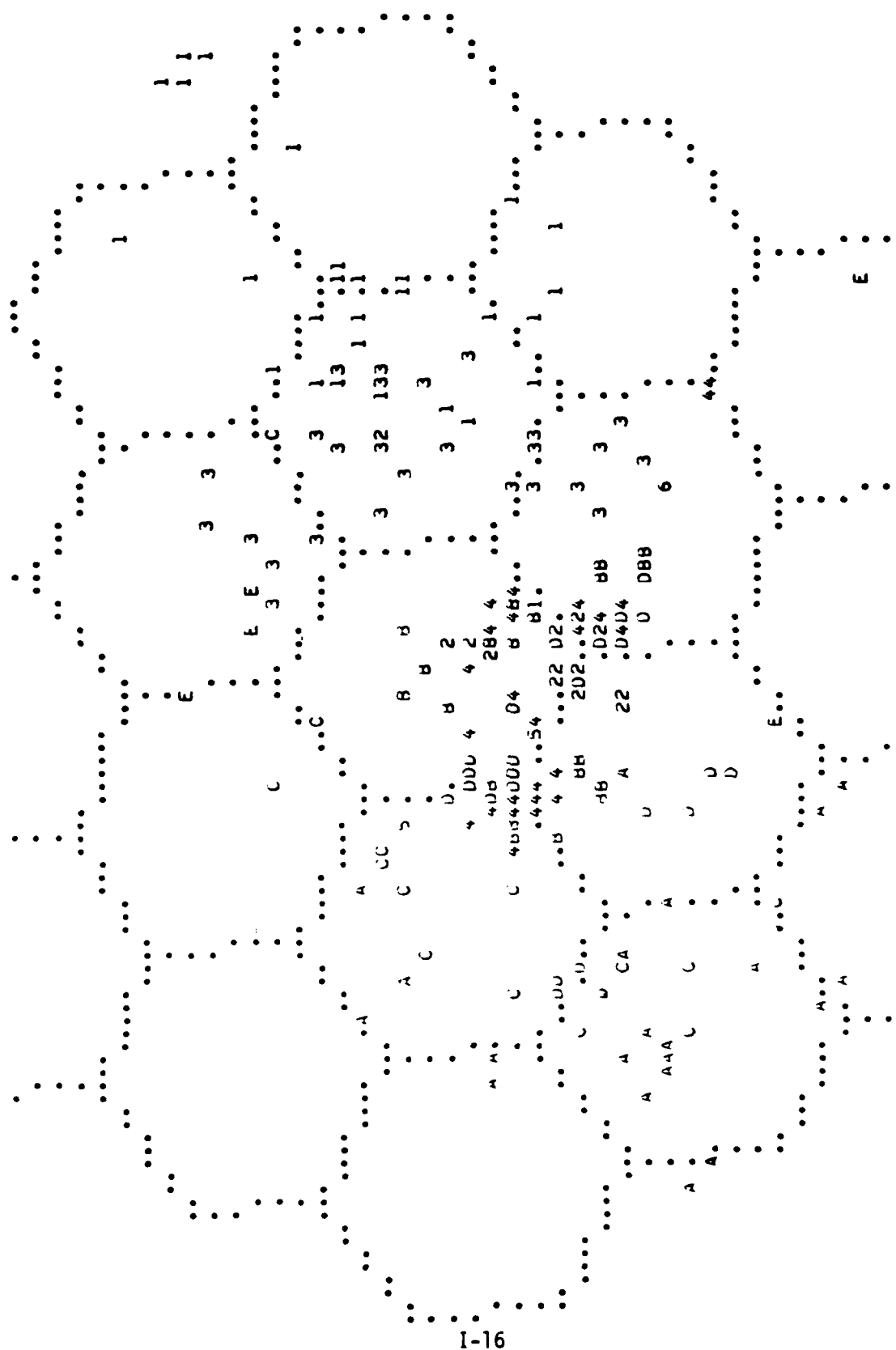
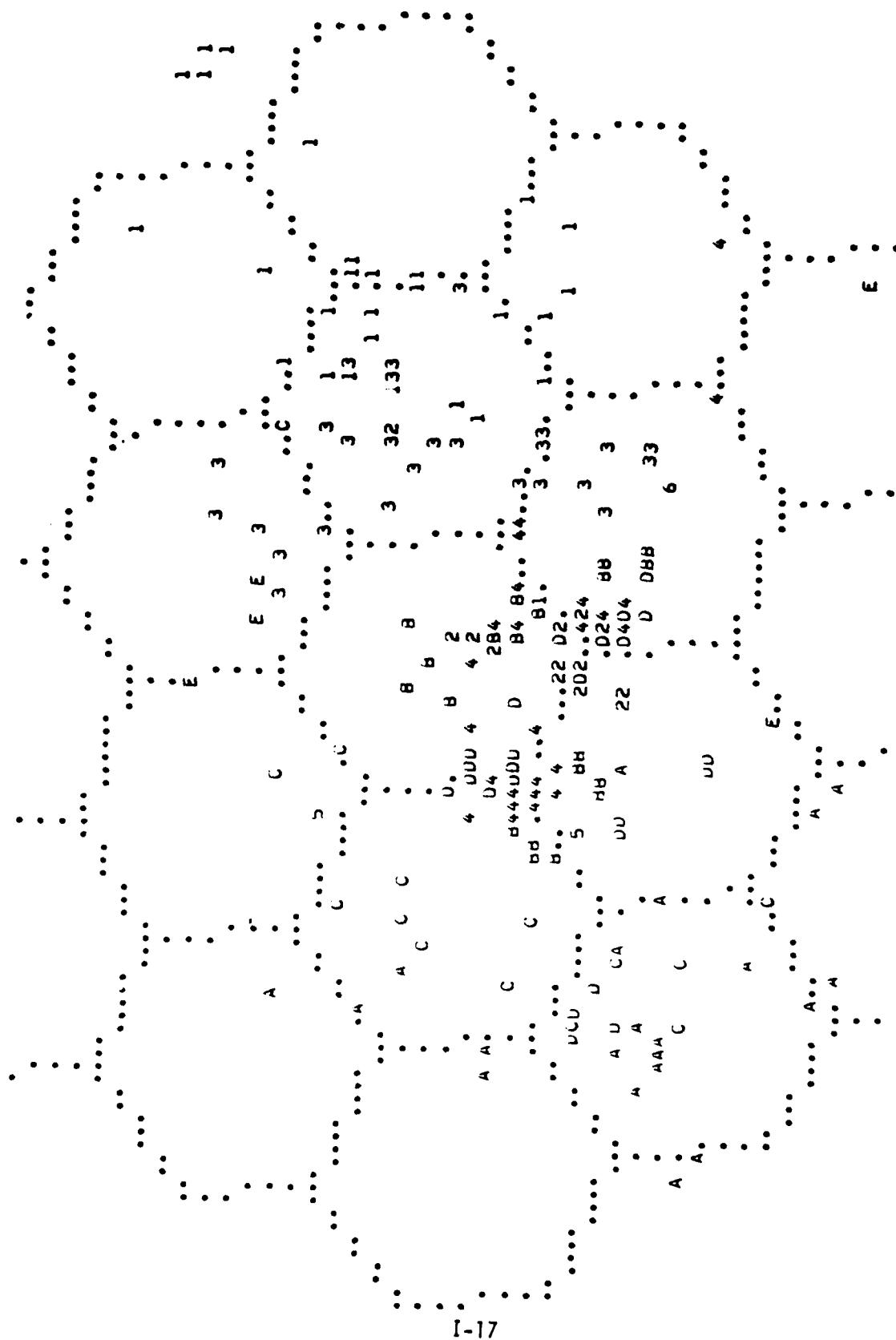


Figure I-15. Case IV unit positions at 07:00 hours.





The quality of the original of this map  
was insufficient to be reproduced.

Figure I-18. Case IV unit positions at 08:30 hours.

APPENDIX J  
CASE III-FP TACTICAL POSITION MAPS

The 18 maps presented in this appendix show the dynamic combat positions of both combatants at the company/battery level from zero to 0830 hours in one-half hour increments. Legend and other pertinent information concerning these maps is the same as for Case I, Appendix F.

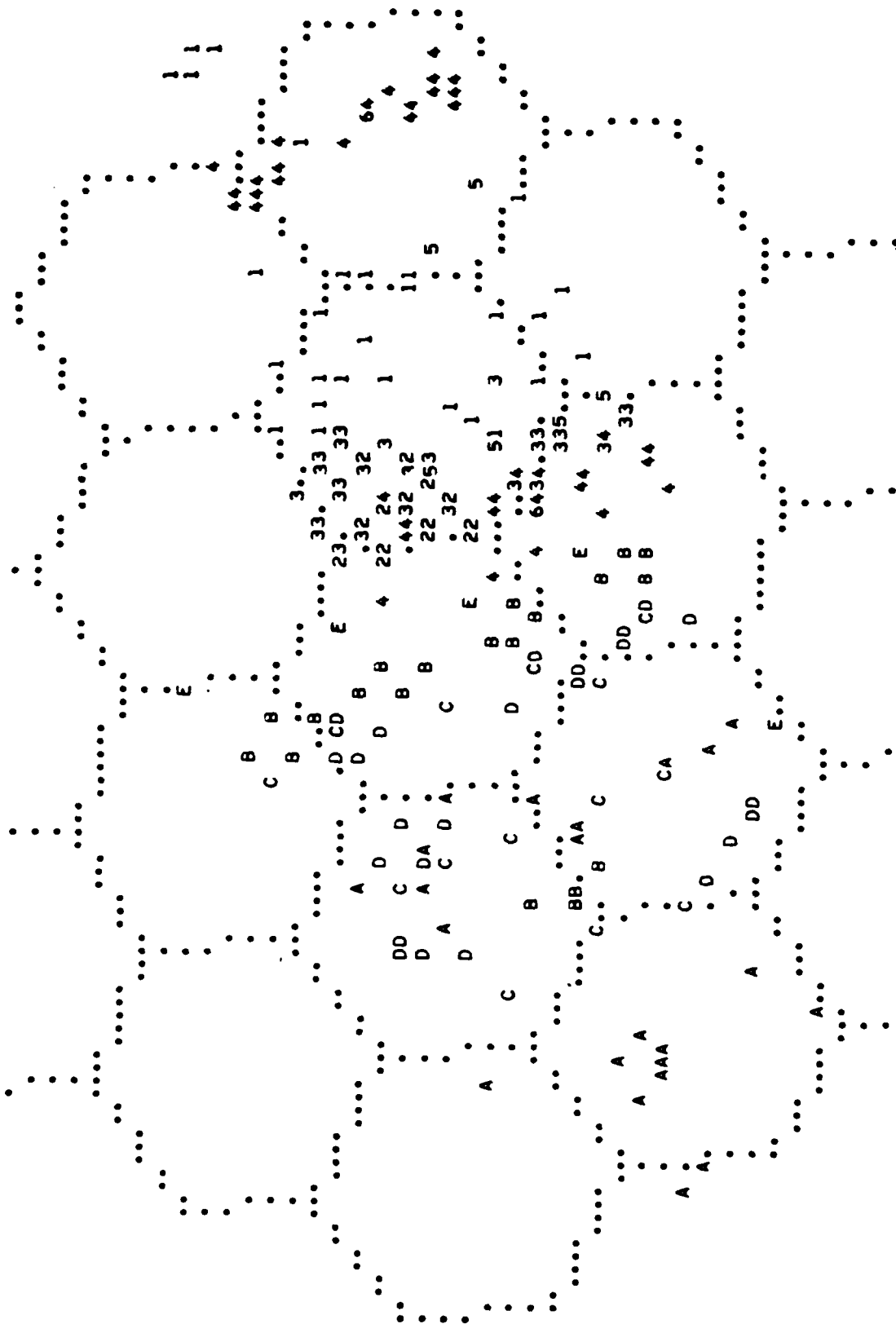


Figure J-1. Case III-FP unit positions at 00:00 hours.



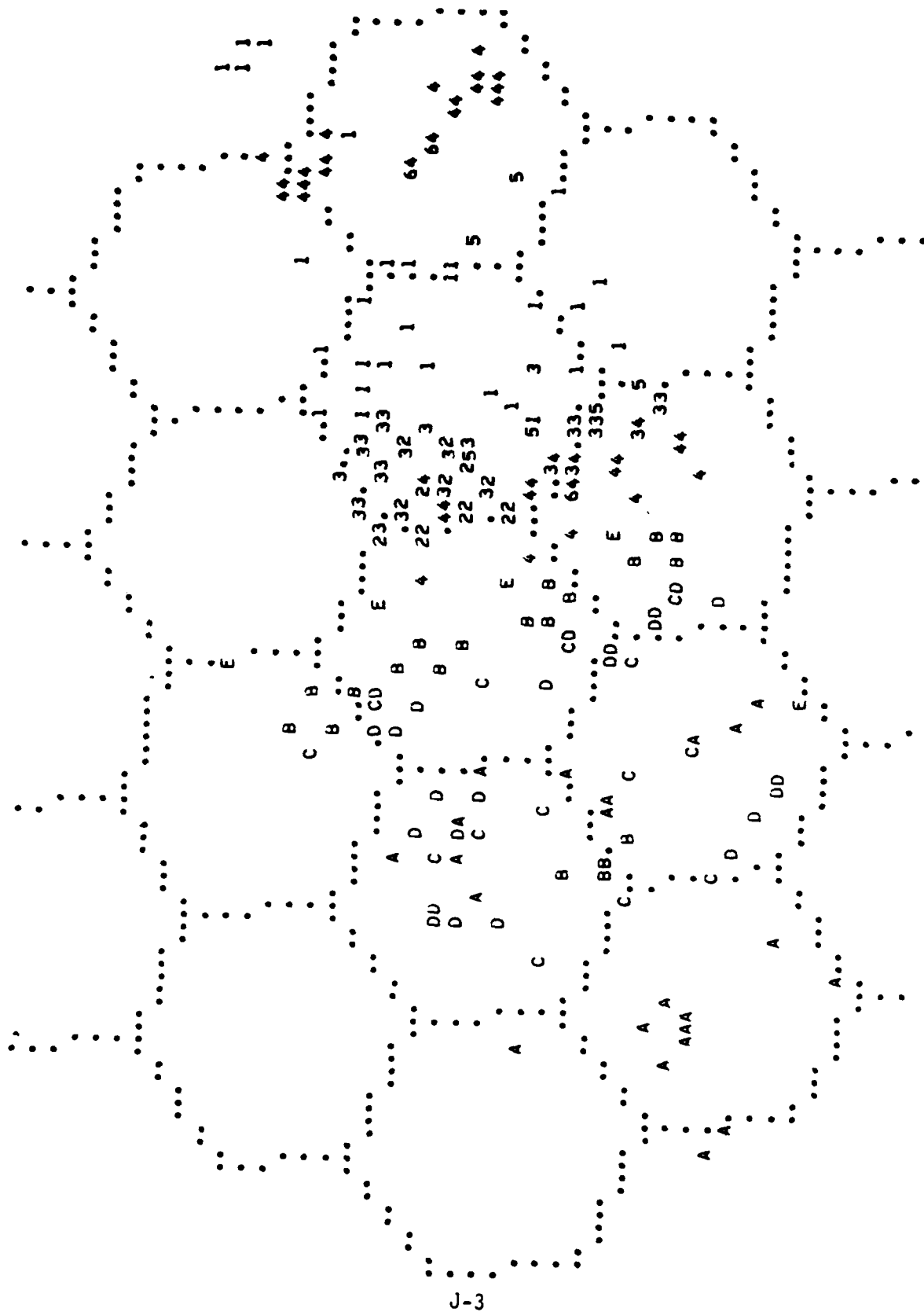


Figure J-2. Case III-FP unit positions at 00:30 hours.

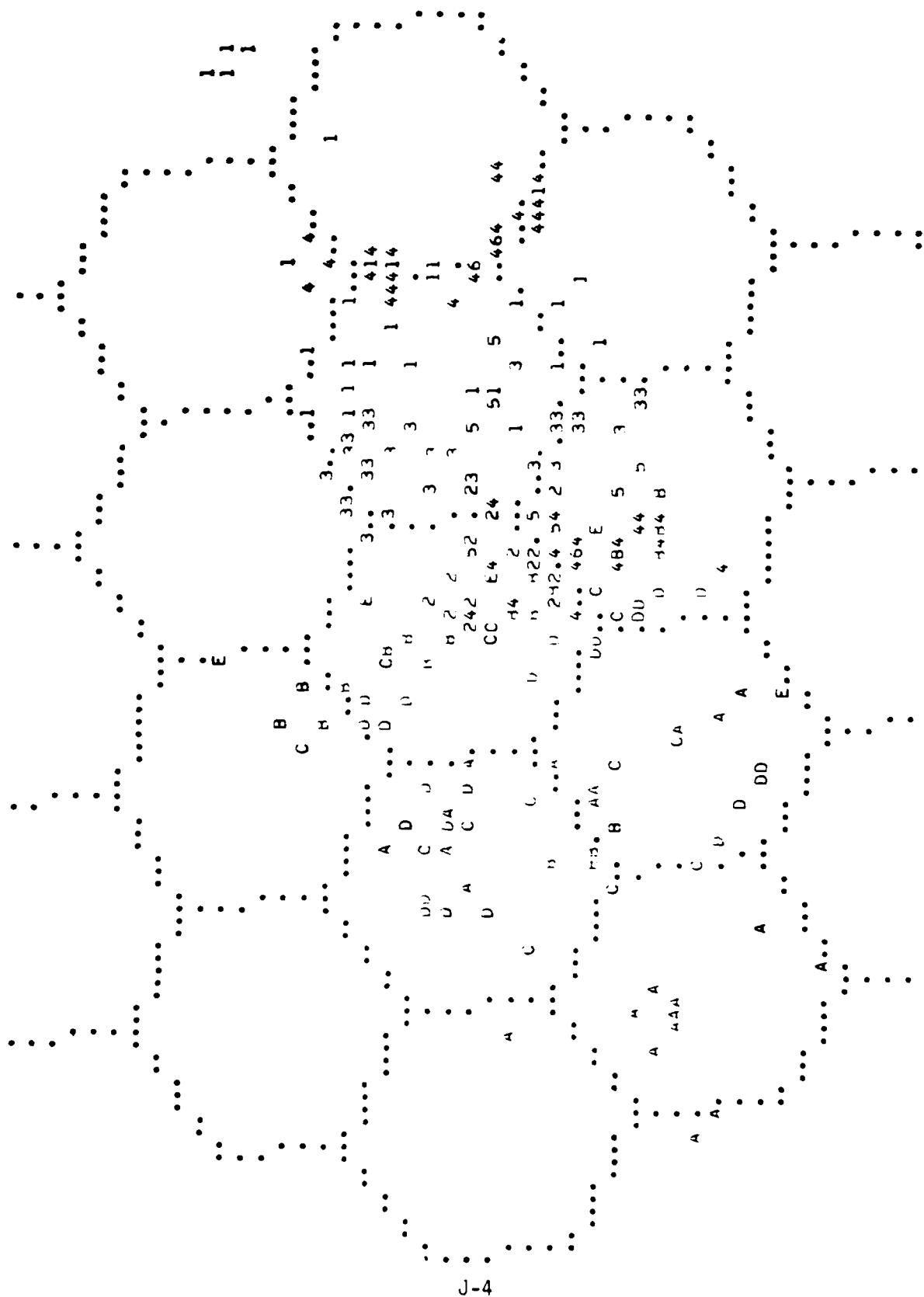


Figure J-3. Case III-FP unit positions at 01:00 hours.

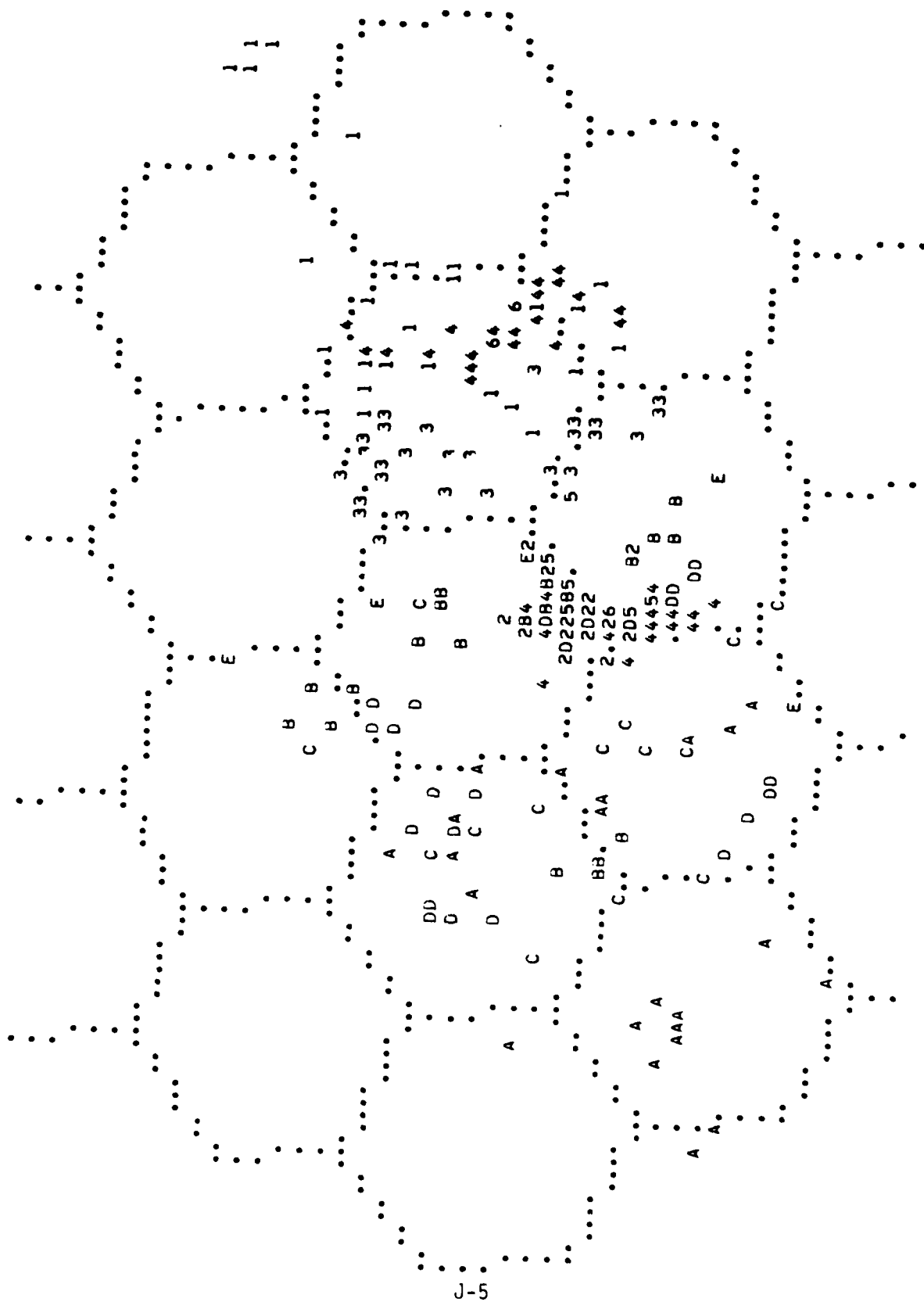


Figure J-4. Case III-FP unit positions at 01:30 hours.

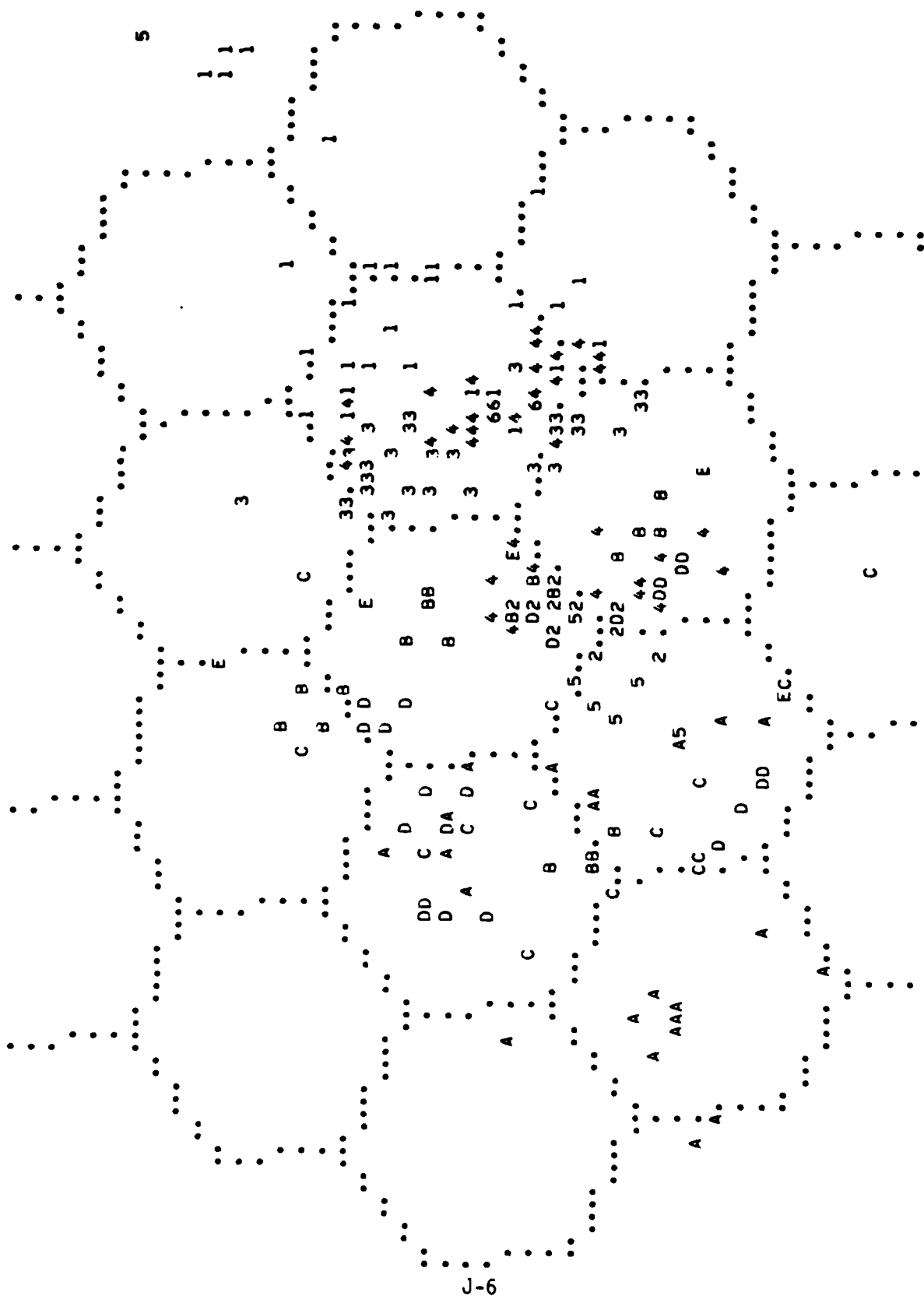


Figure J-5. Case III-FP unit positions at 02:00 hours.

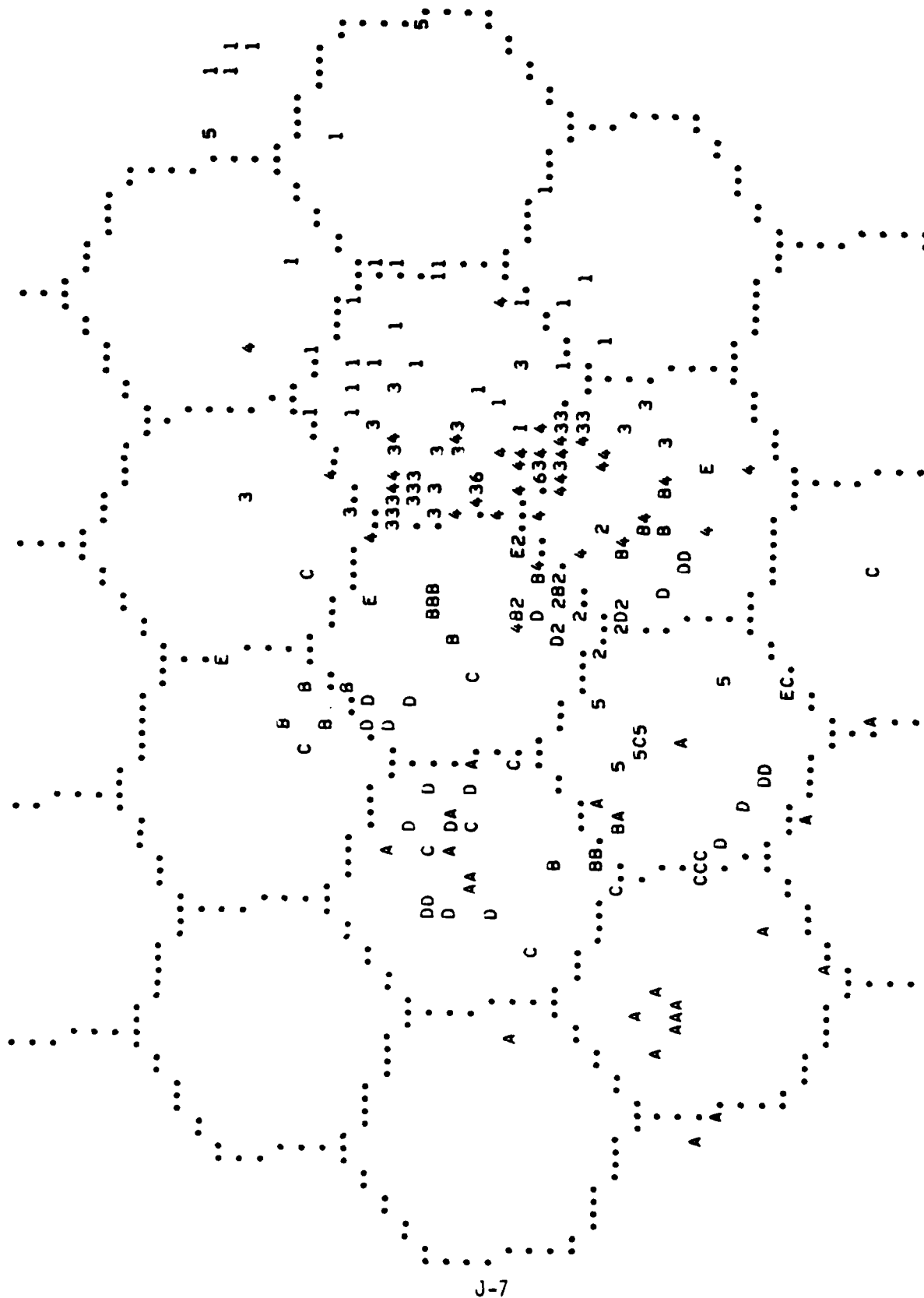


Figure J-6. Case III-FP unit positions at 02:30 hours.

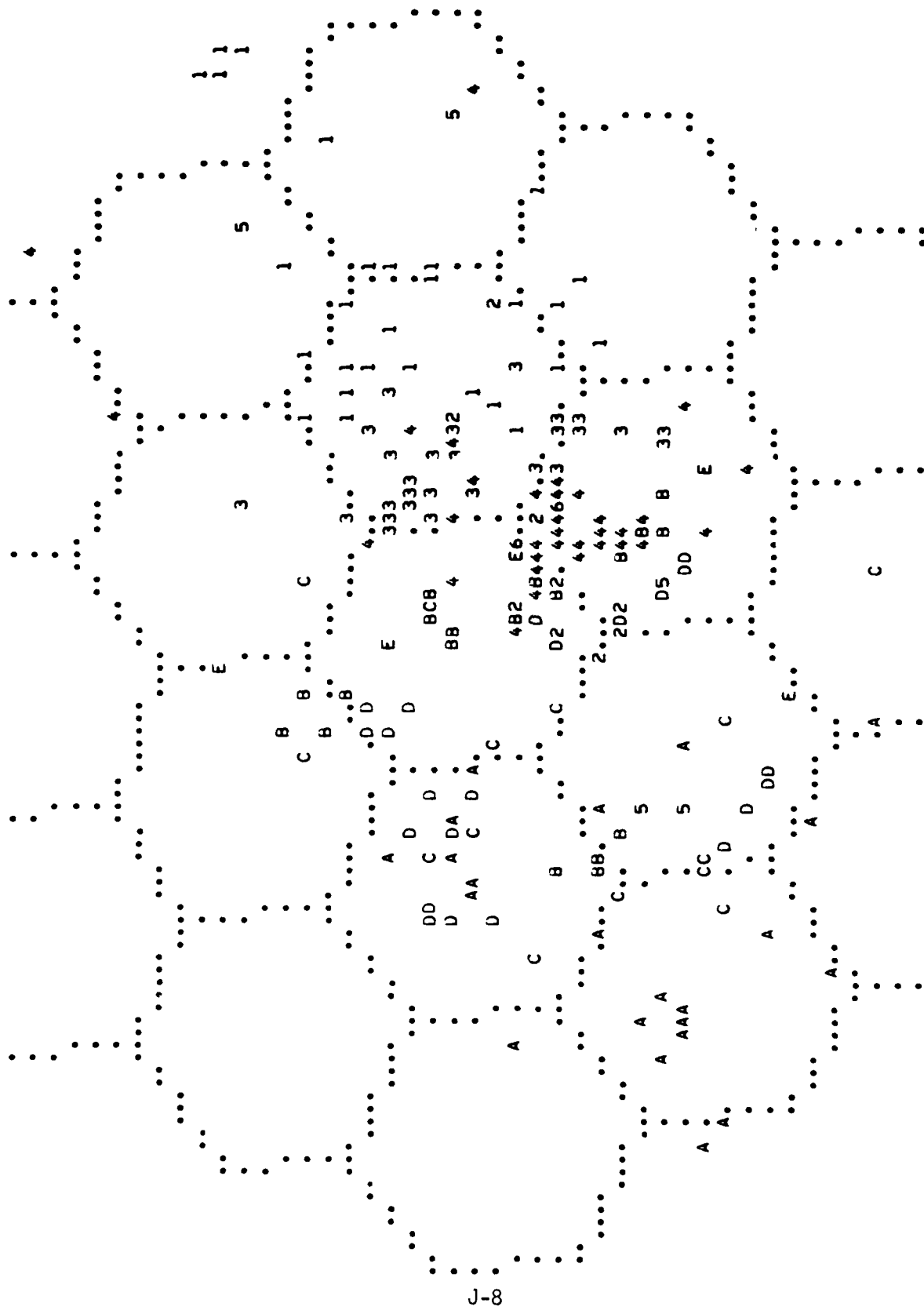


Figure J-7. Case III-FP unit positions at 03:00 hours.

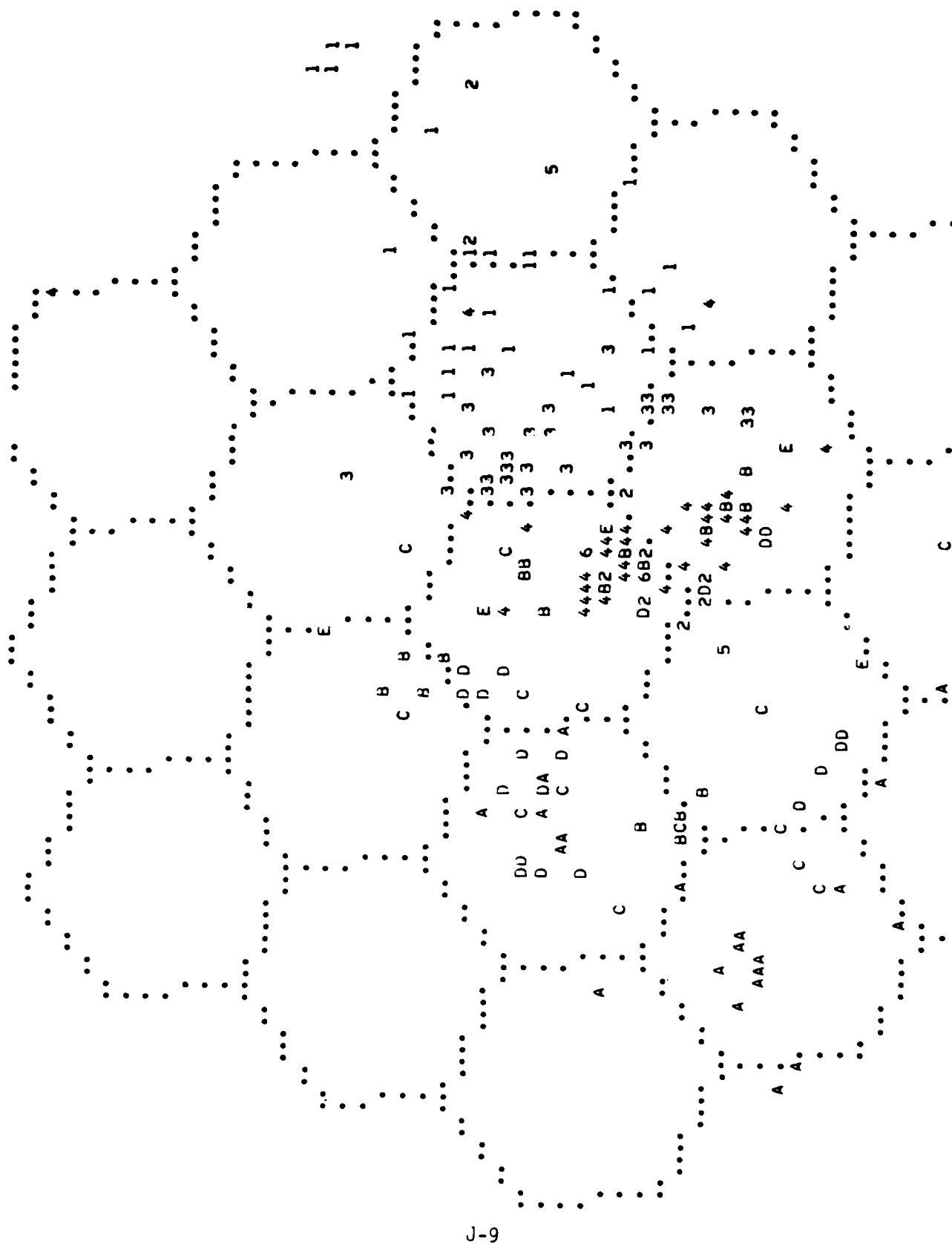


Figure J-8. Case III-FP unit positions at 03:30 hours.

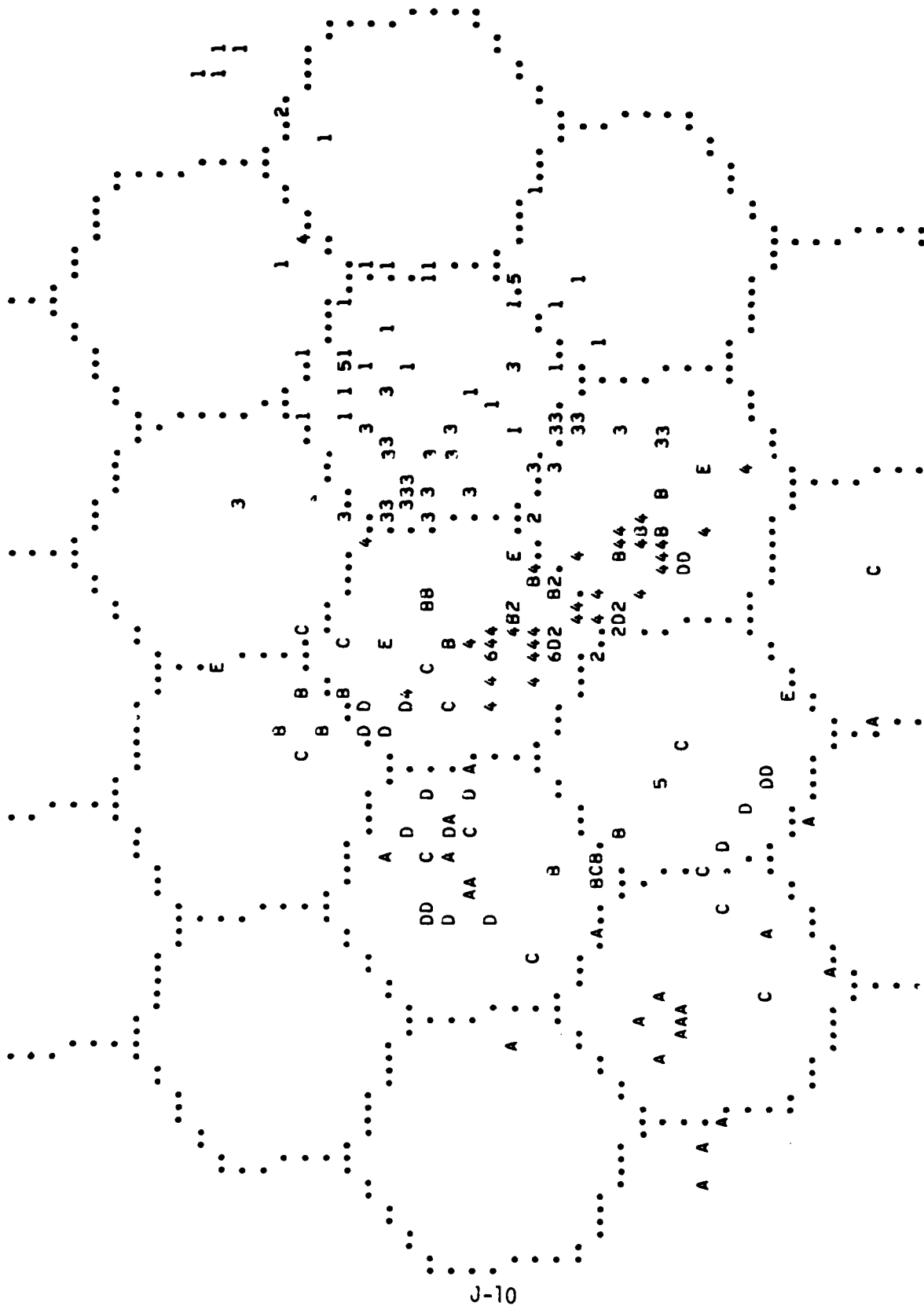


Figure J-9. Case III-FP unit positions at 04:00 hours.



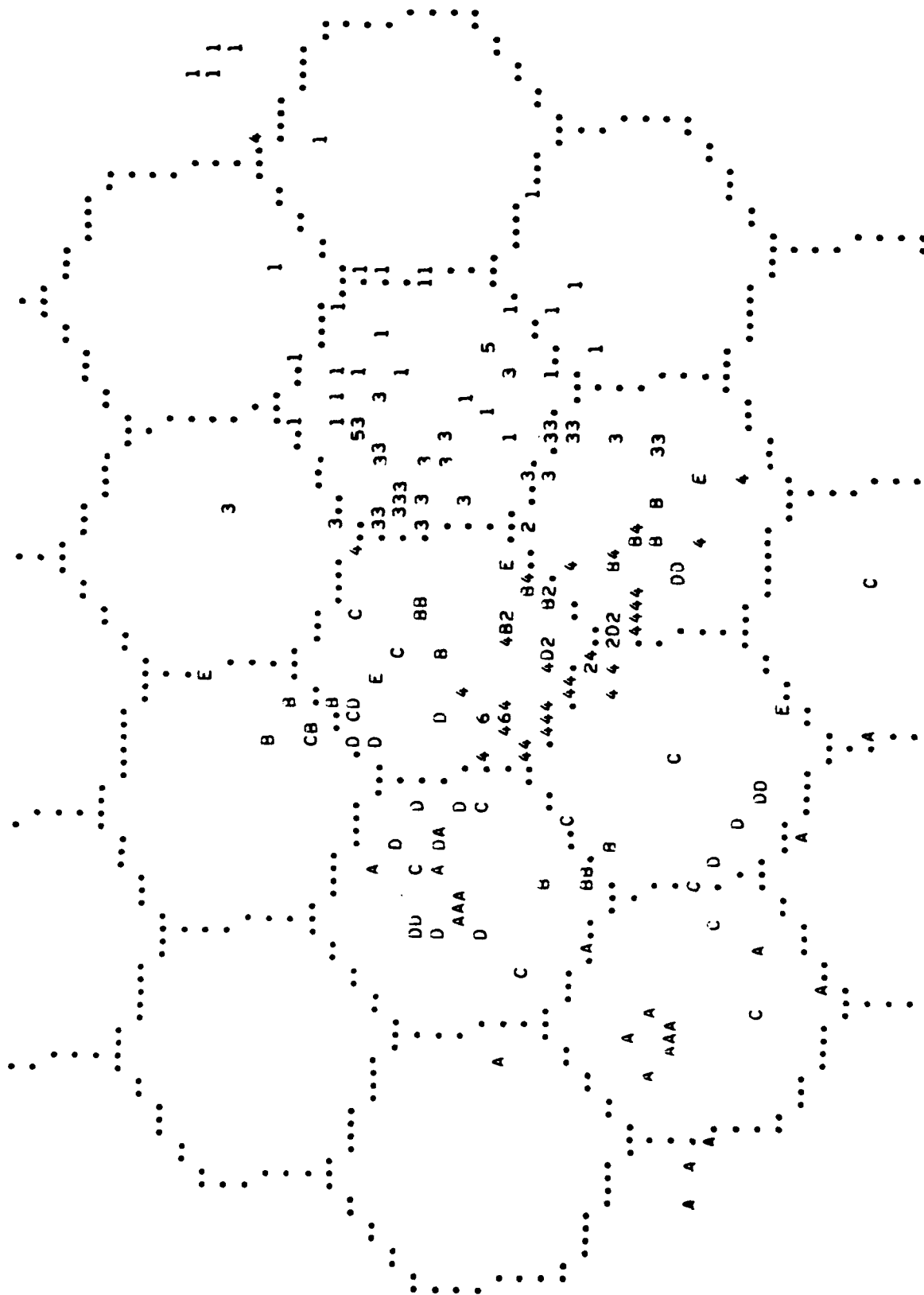


Figure J-10. Case III-FP unit positions at 04:30 hours.

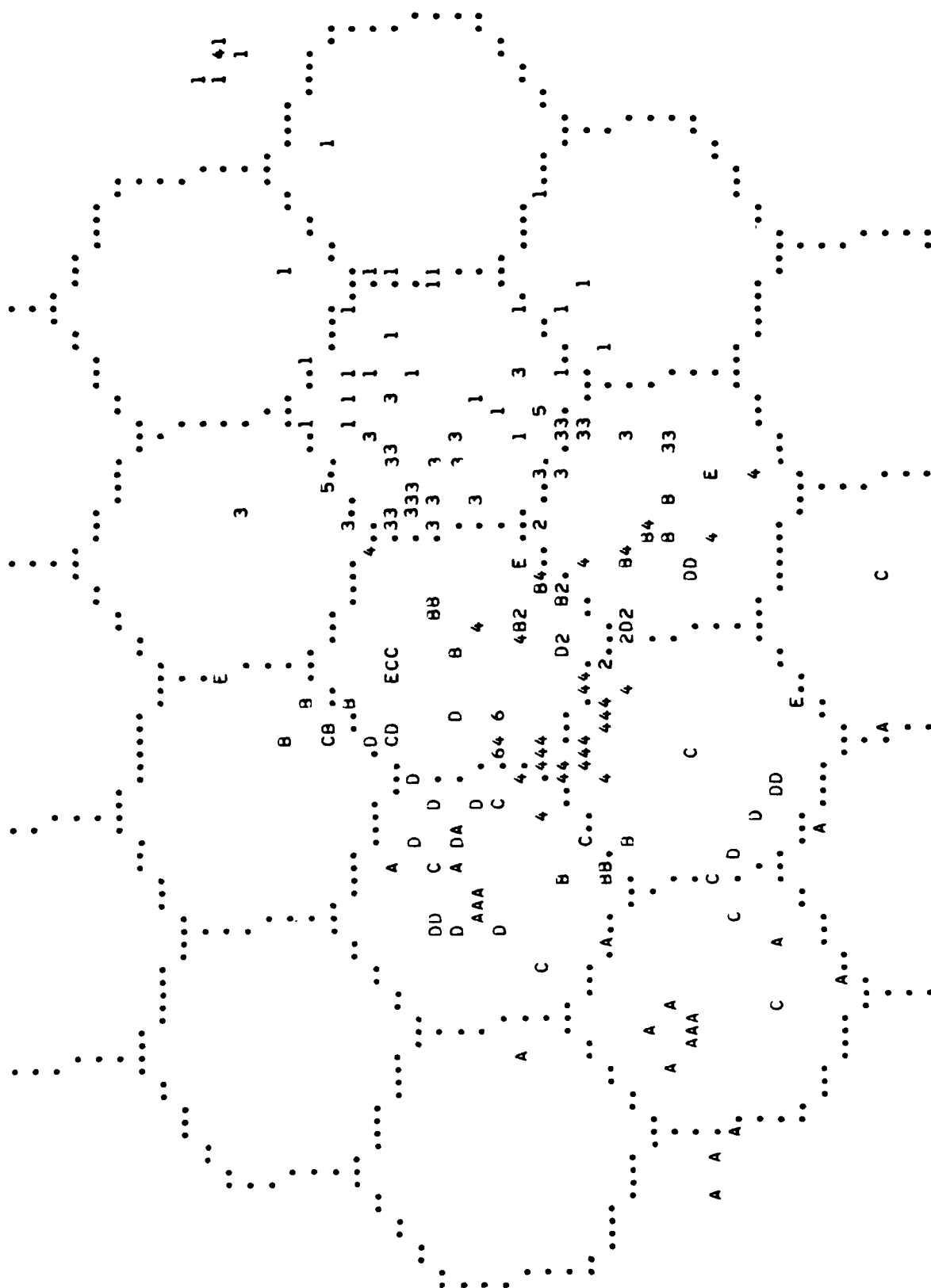


Figure J-11. Case III-FP unit positions at 05:00 hours.

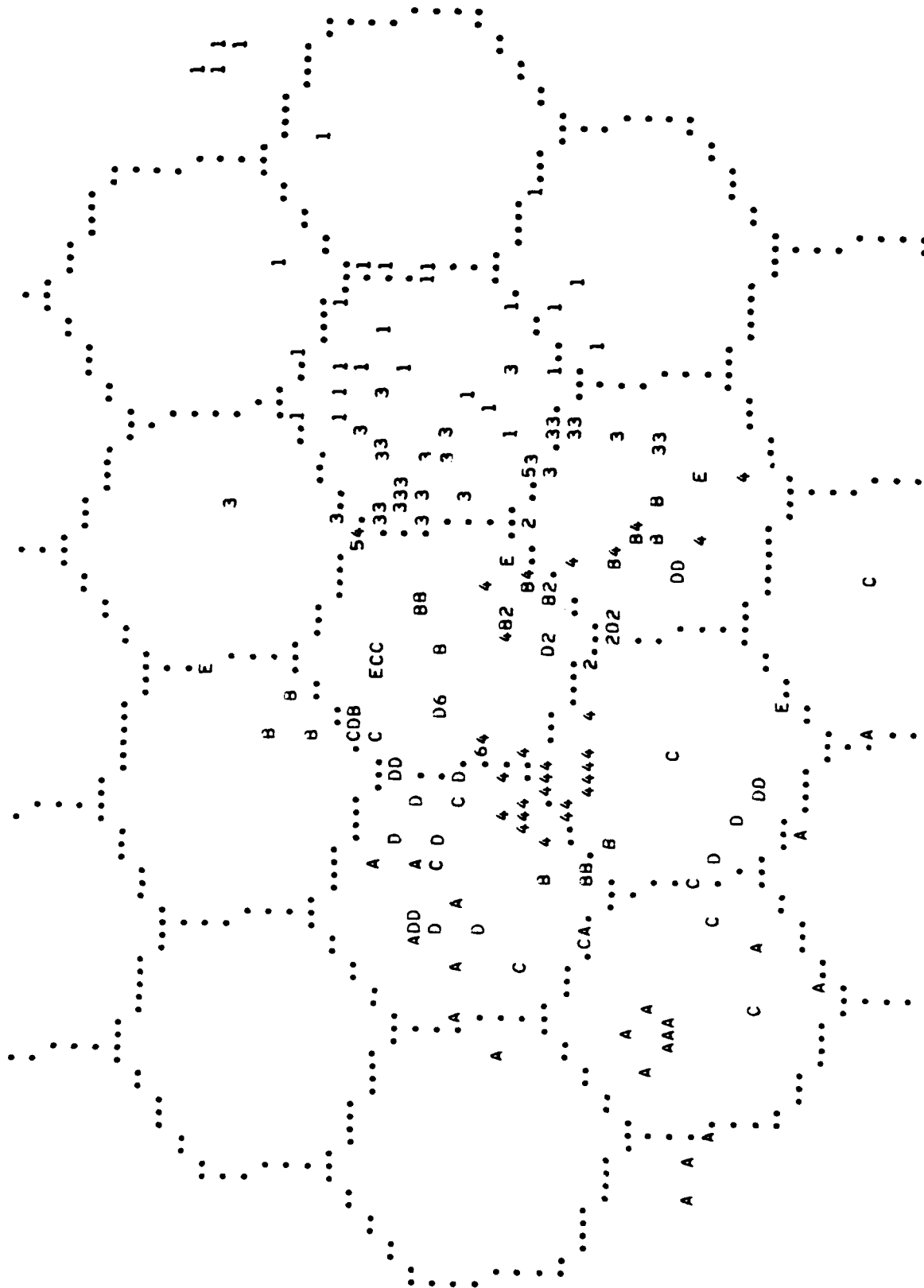


Figure J-12. Case III-FP unit positions at 05:30 hours.

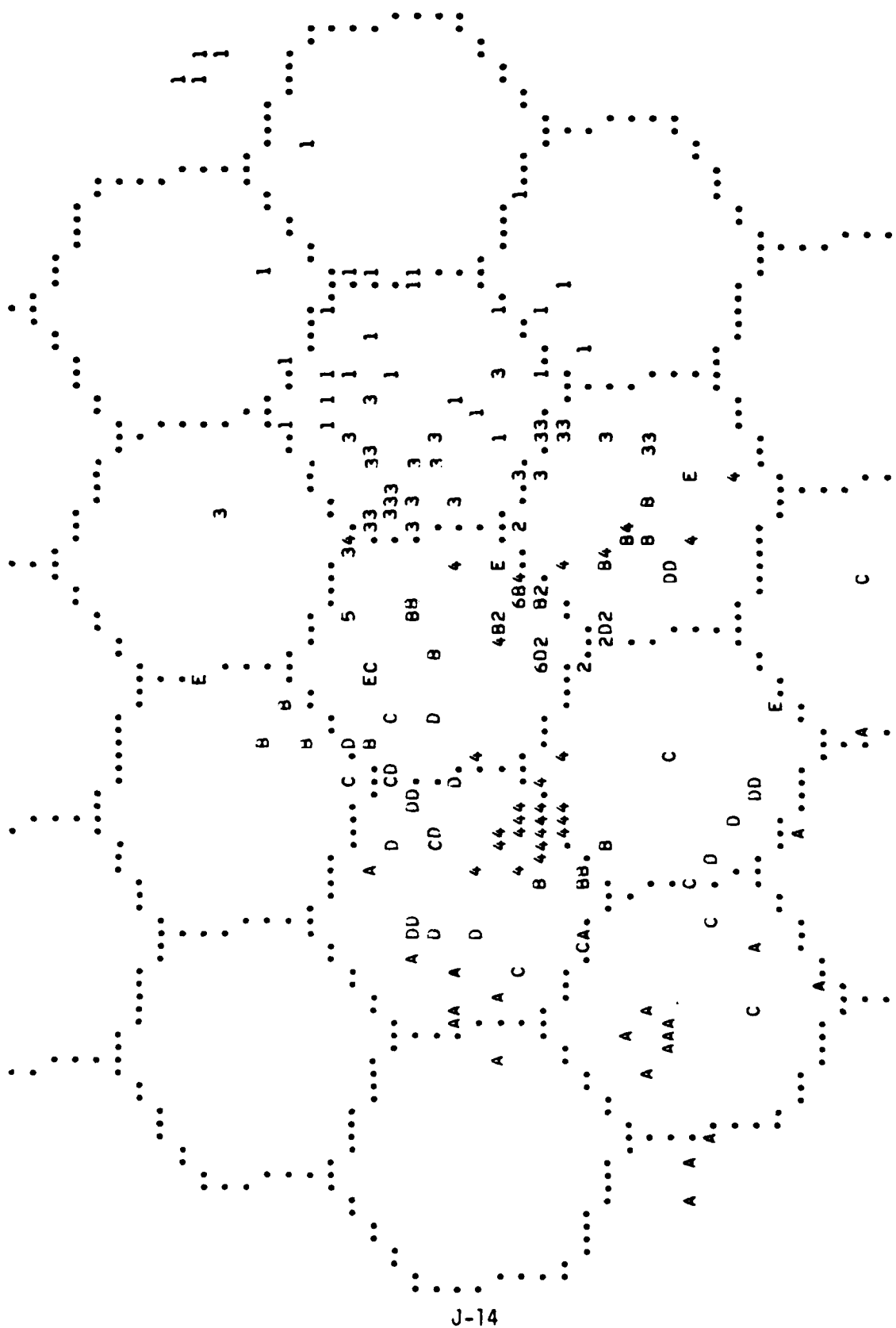


Figure J-13. Case III-FP unit positions at 06:00 hours.

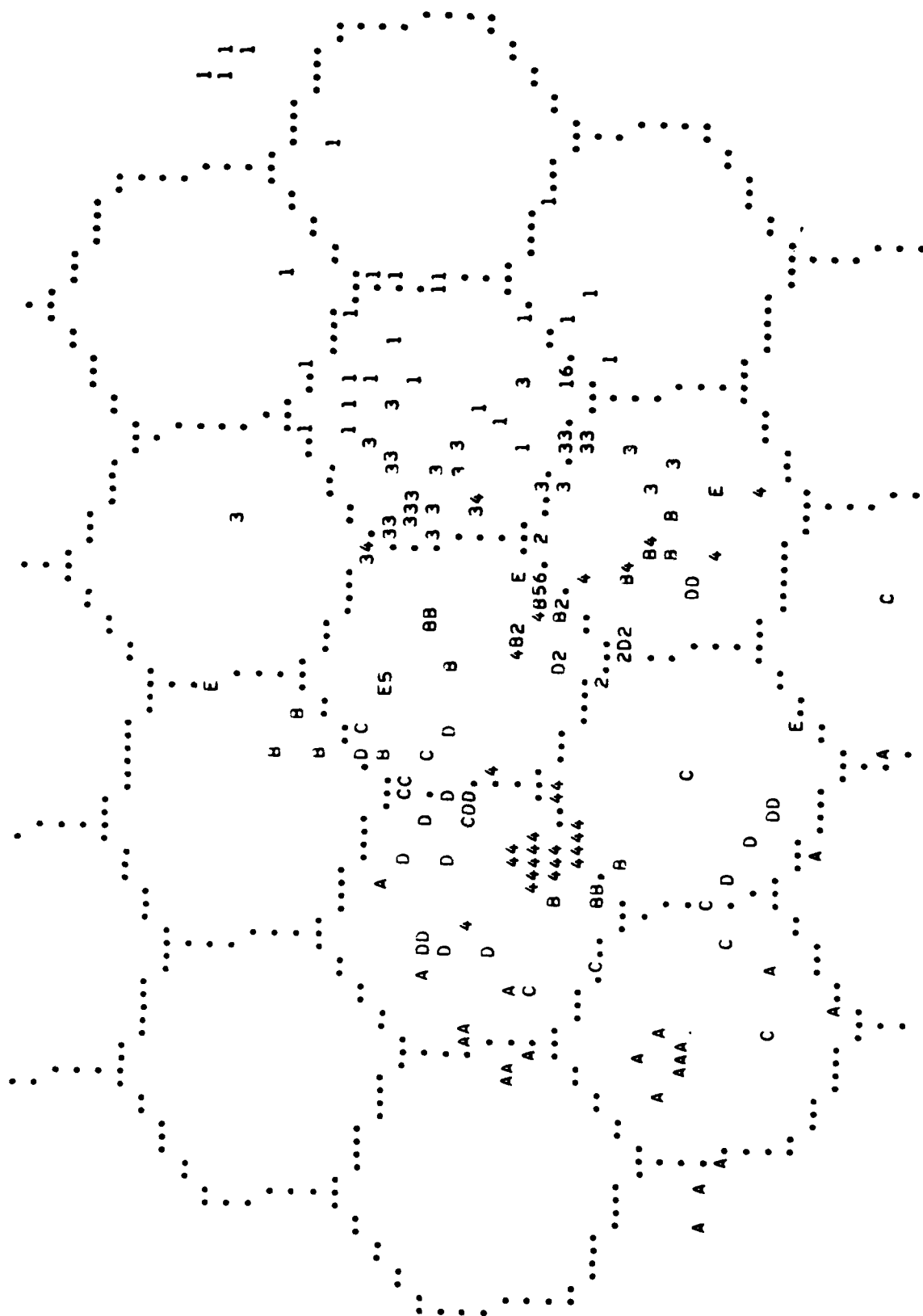


Figure J-14. Case III-FP unit positions at 06:30 hours.

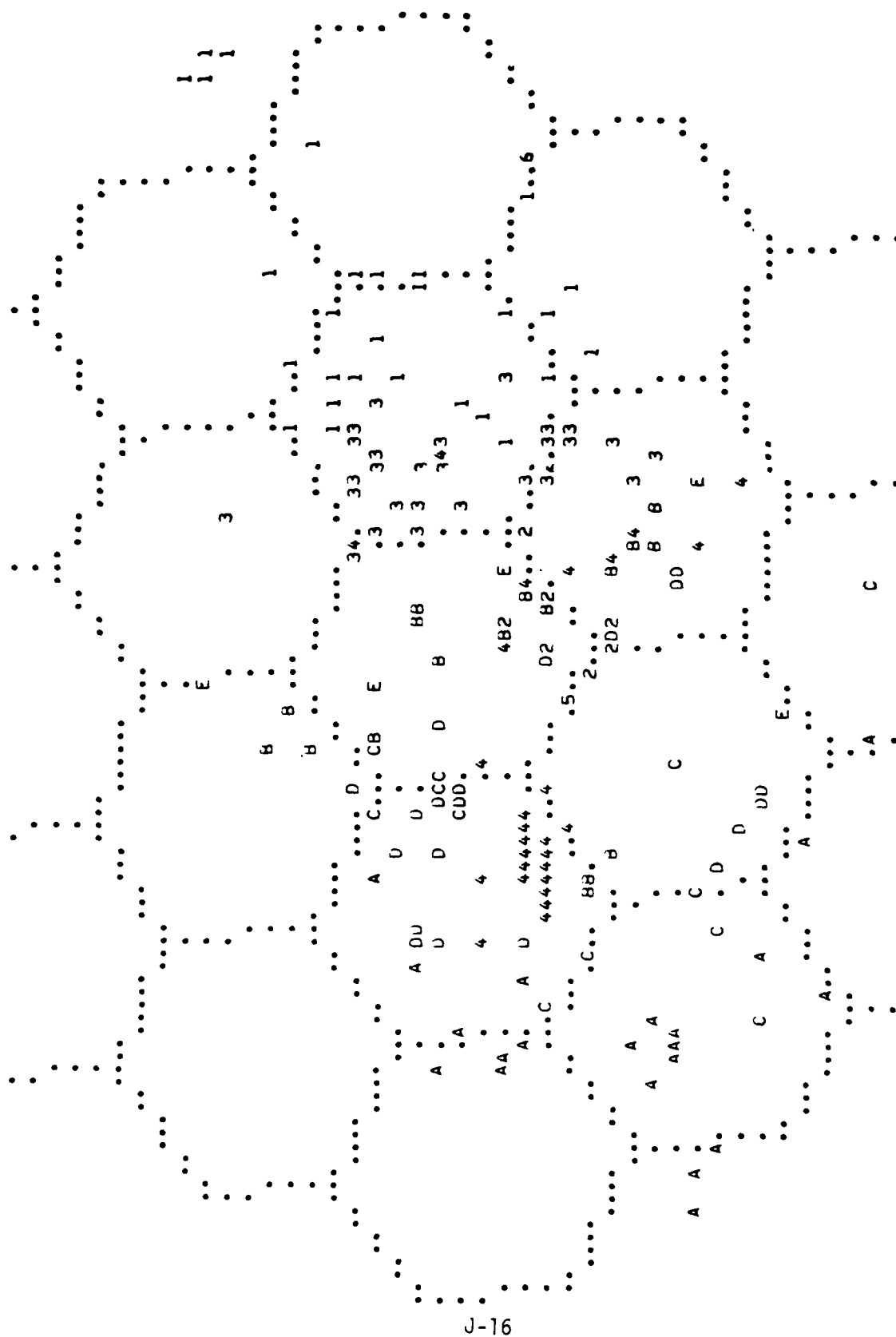


Figure J-15. Case III-FP unit positions at 07:00 hours.

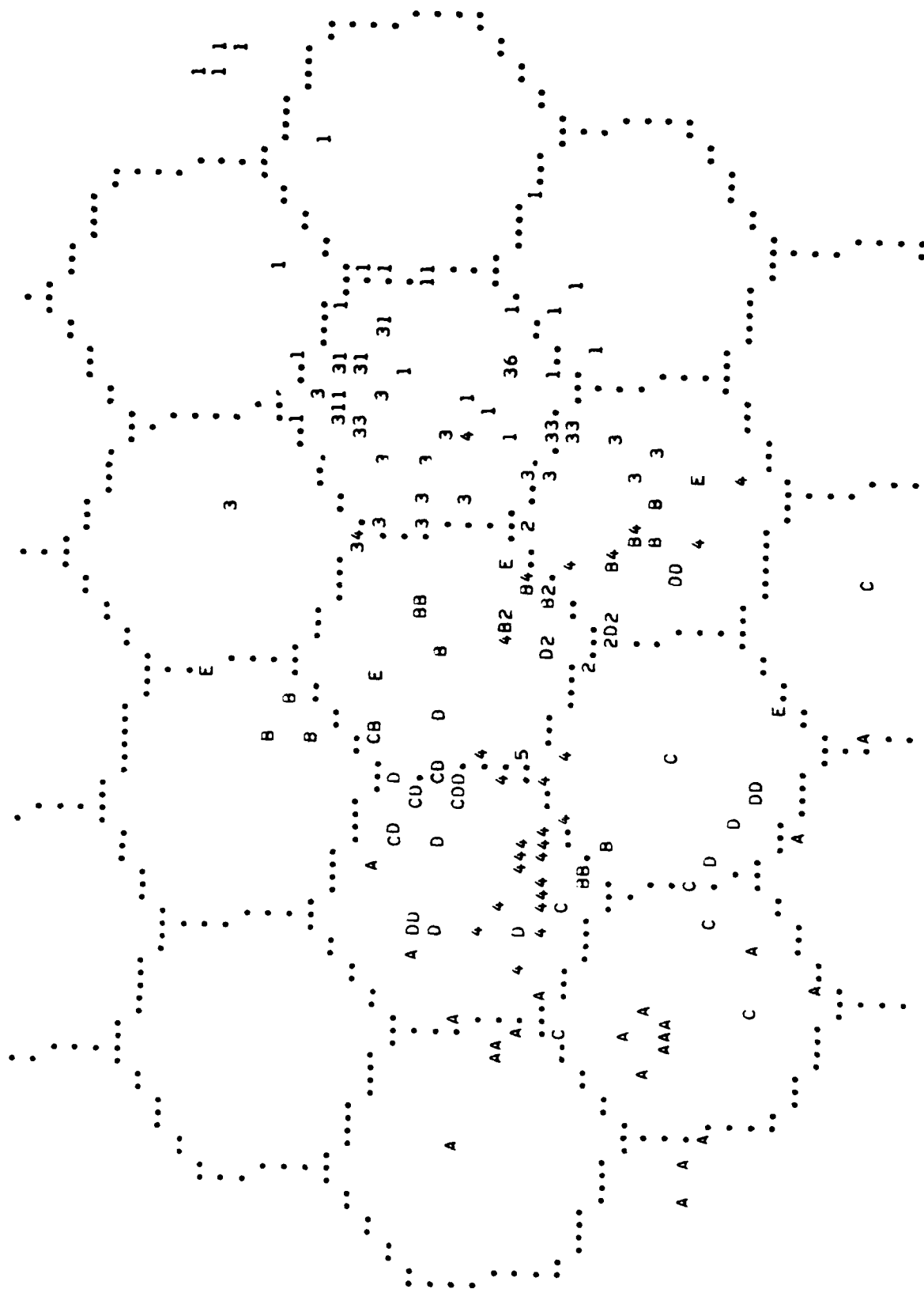


Figure J-16. Case III-FP unit positions at 07:30 hours.

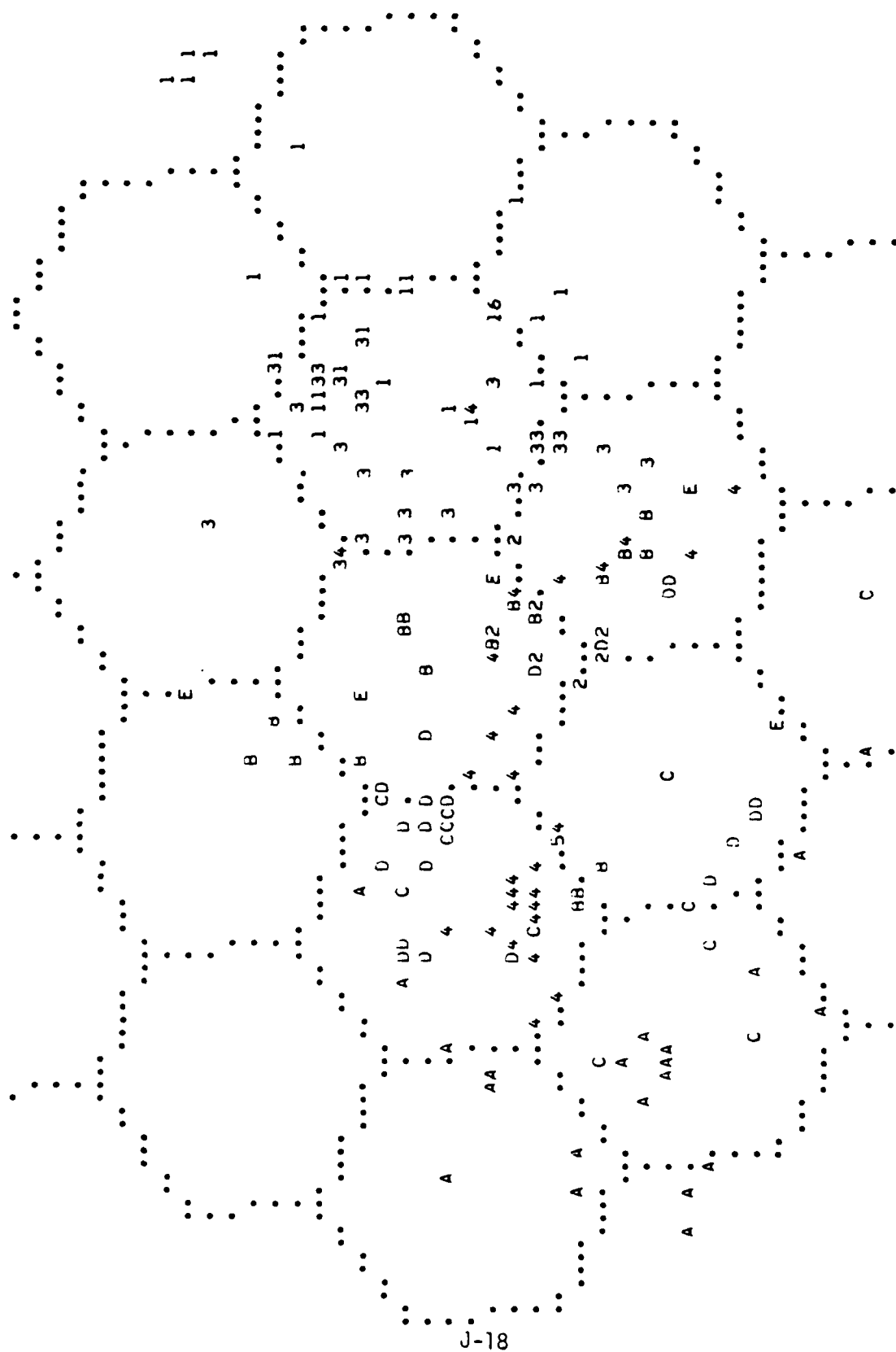


Figure J-17. Case III-FP unit positions at 08:00 hours.



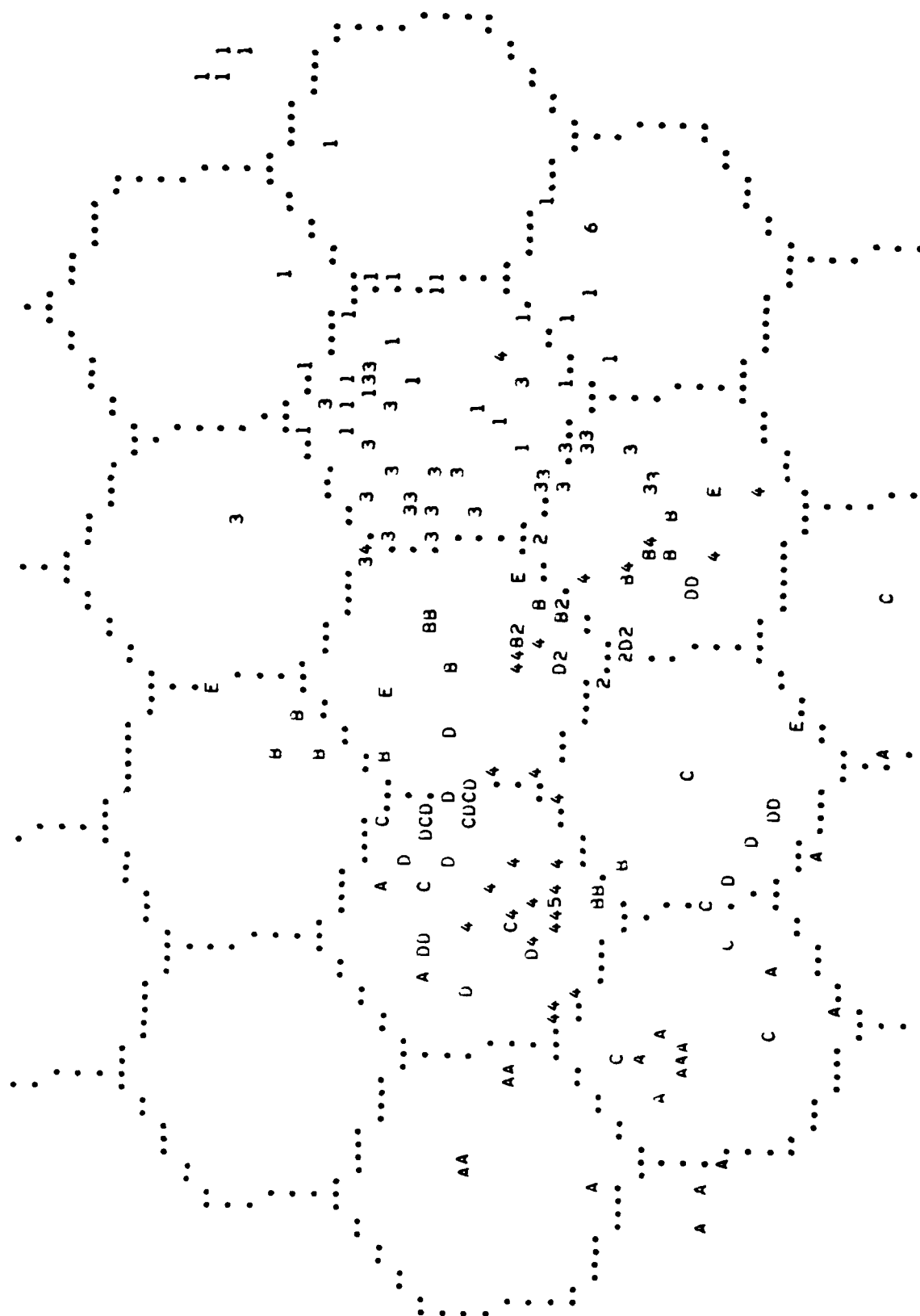


Figure J-18. Case III-FP unit positions at 08:30 hours.

APPENDIX K  
CASE IV-FP TACTICAL POSITION MAPS

The 18 maps presented in this appendix show the dynamic combat positions of both combatants at the company/battery level from zero to 0830 hours in one-half hour increments. Legend and other pertinent information concerning these maps is the same as for Case I, Appendix F.

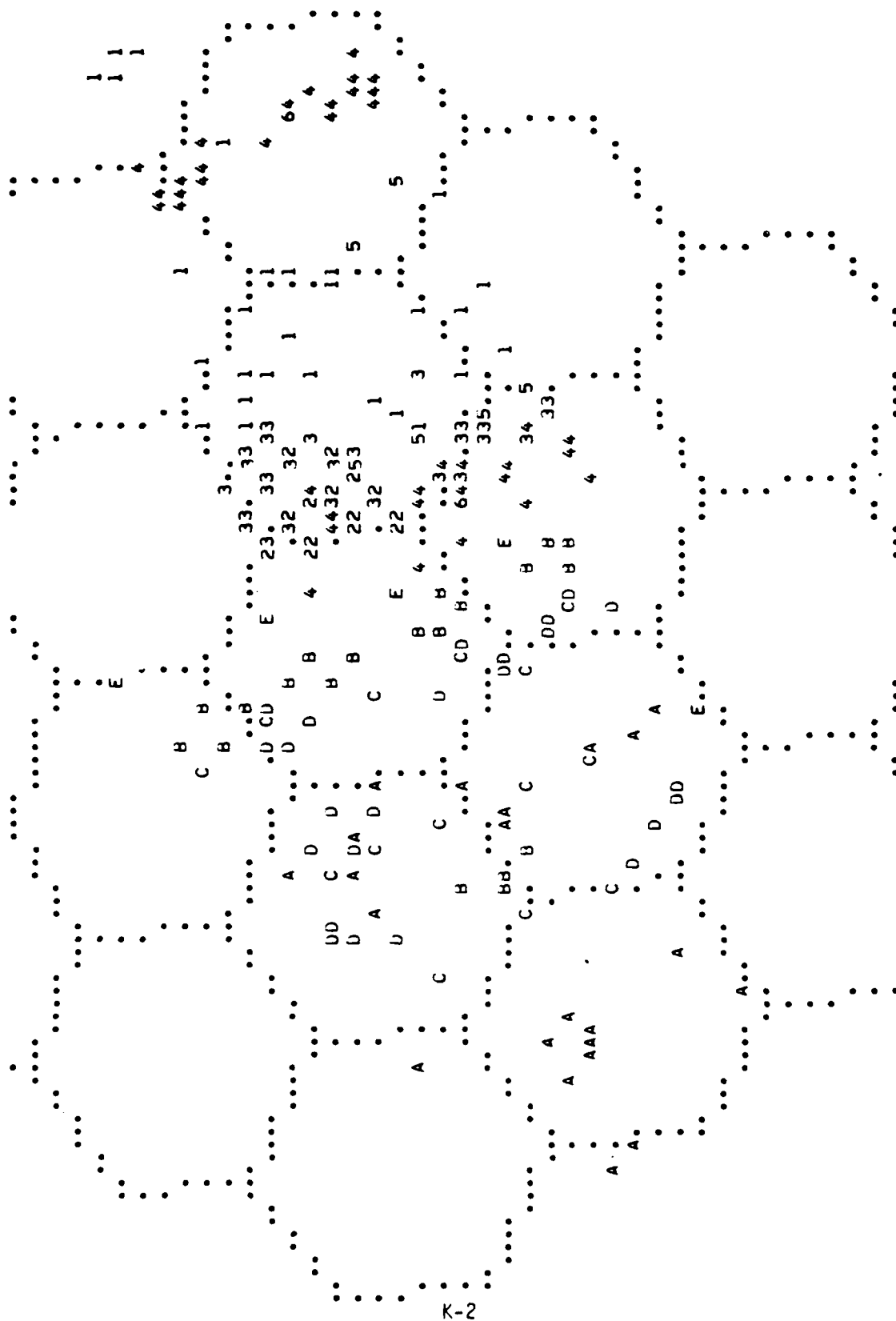


Figure K-1. Case IV-FP unit positions at 00:00 hours.

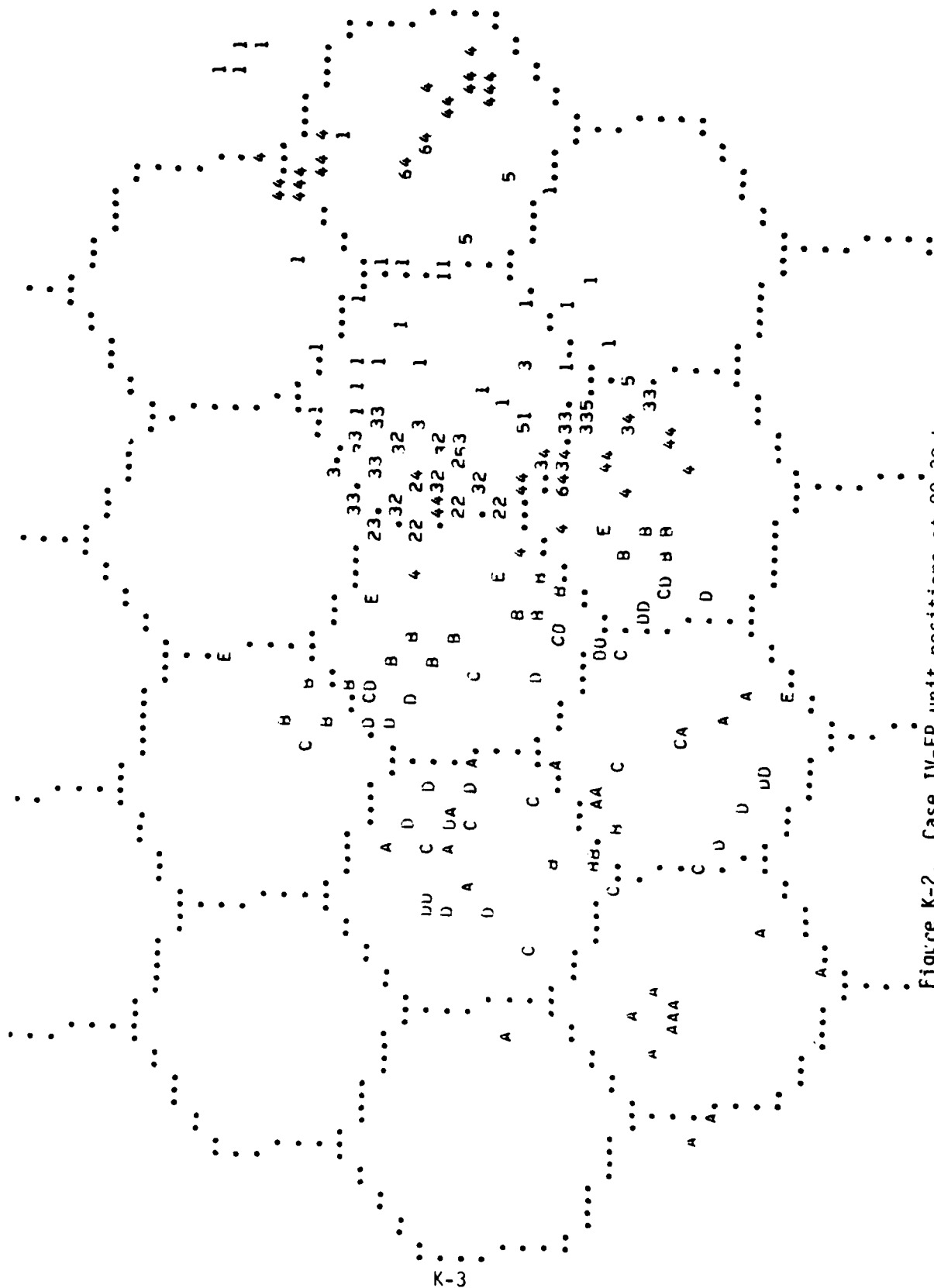


Figure K-2. Case IV-FP unit positions at 00:30 hours.

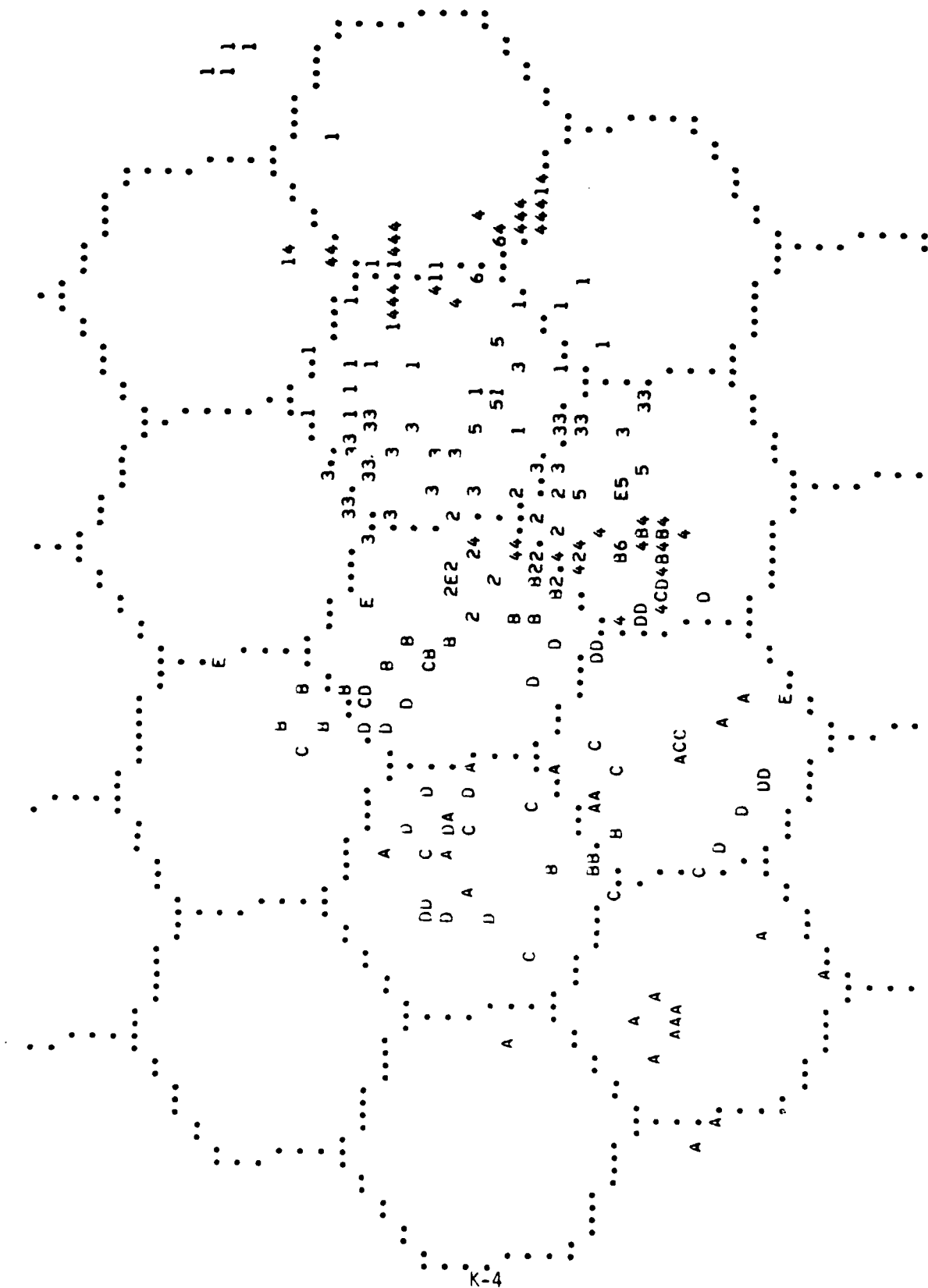


Figure K-3. Case IV-FP unit positions at 01:00 hours.

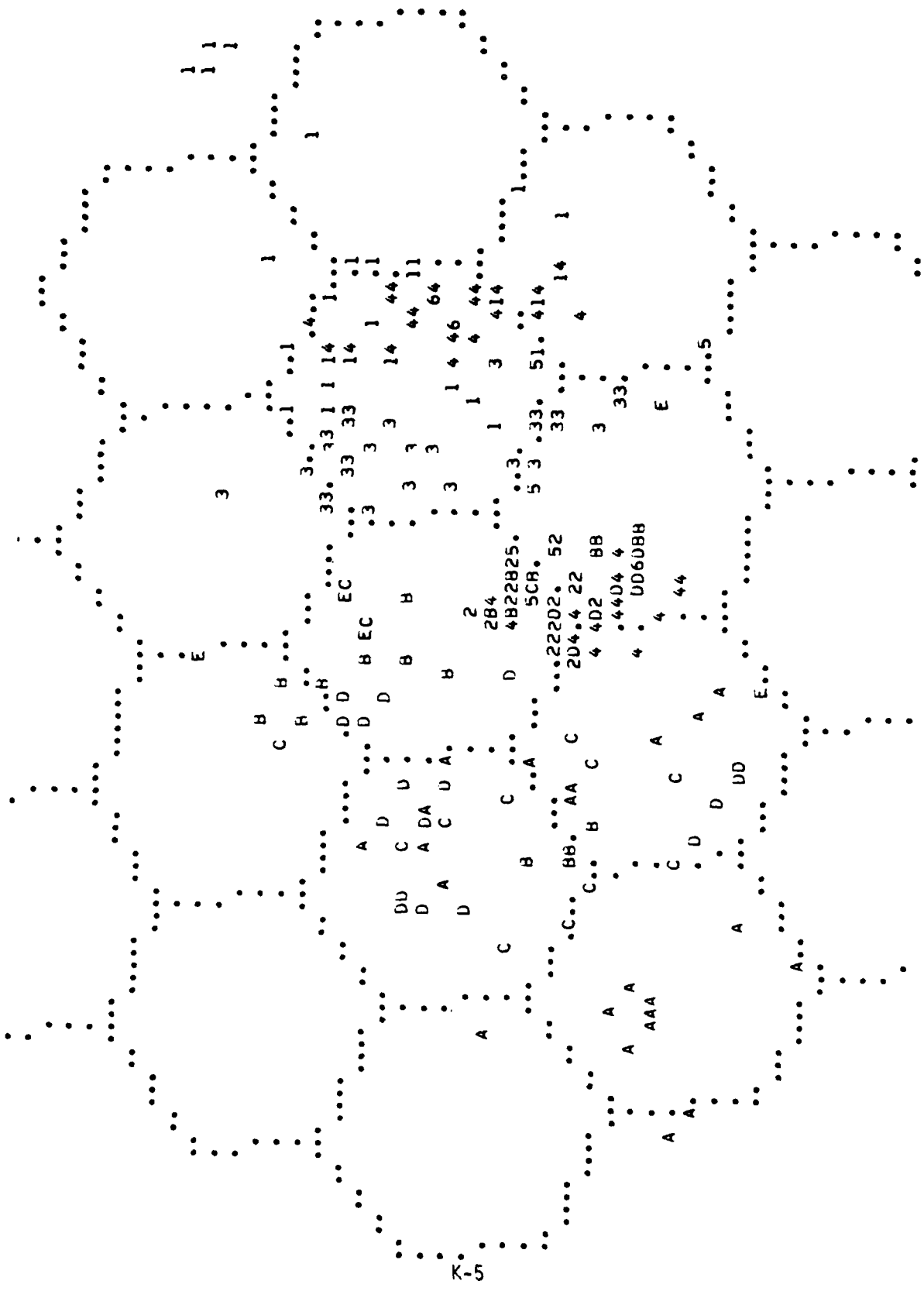


Figure K-4. Case IV-FP unit positions at 01:30 hours.

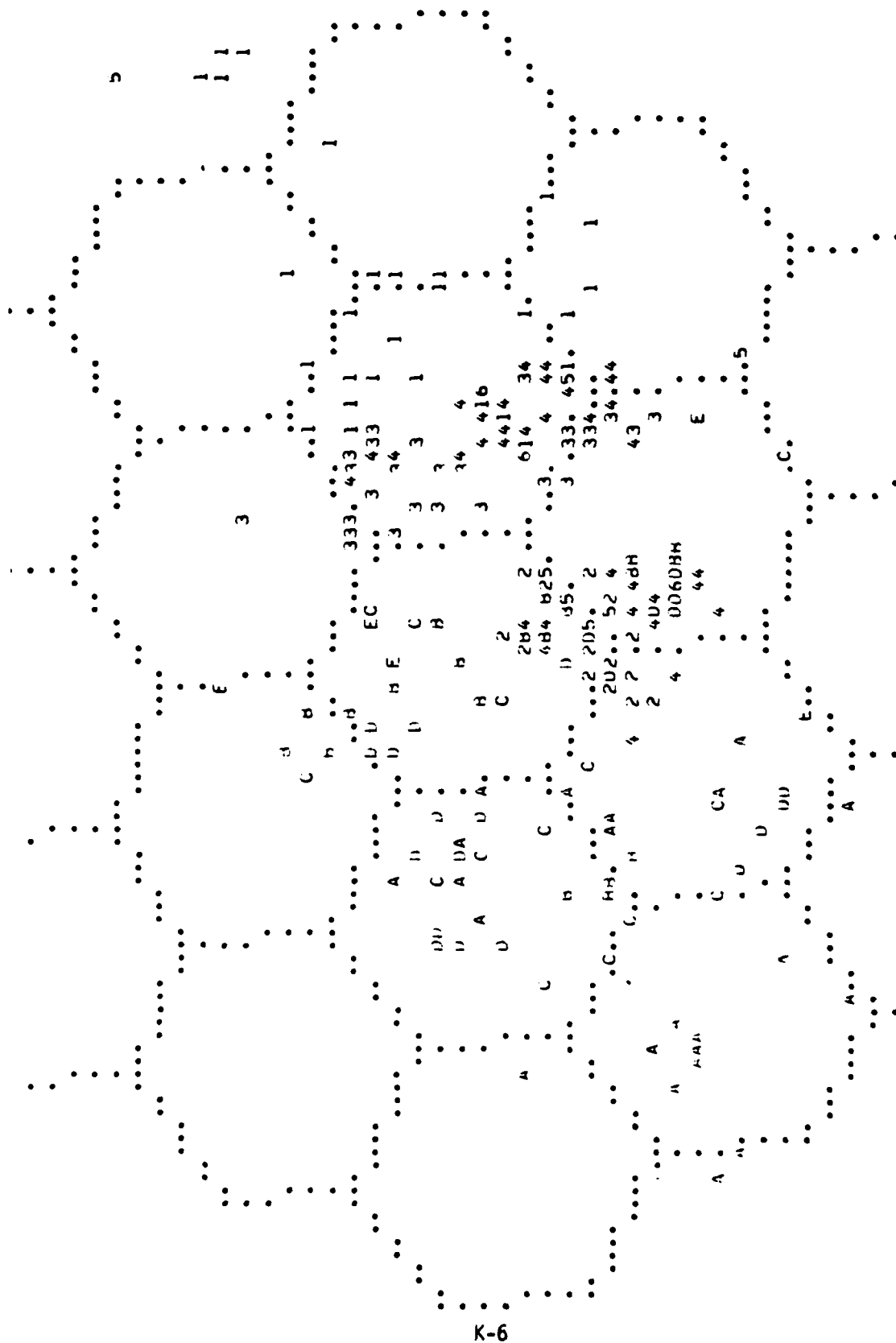


Figure K-5. Case IV-FP unit positions at 02:00 hours.

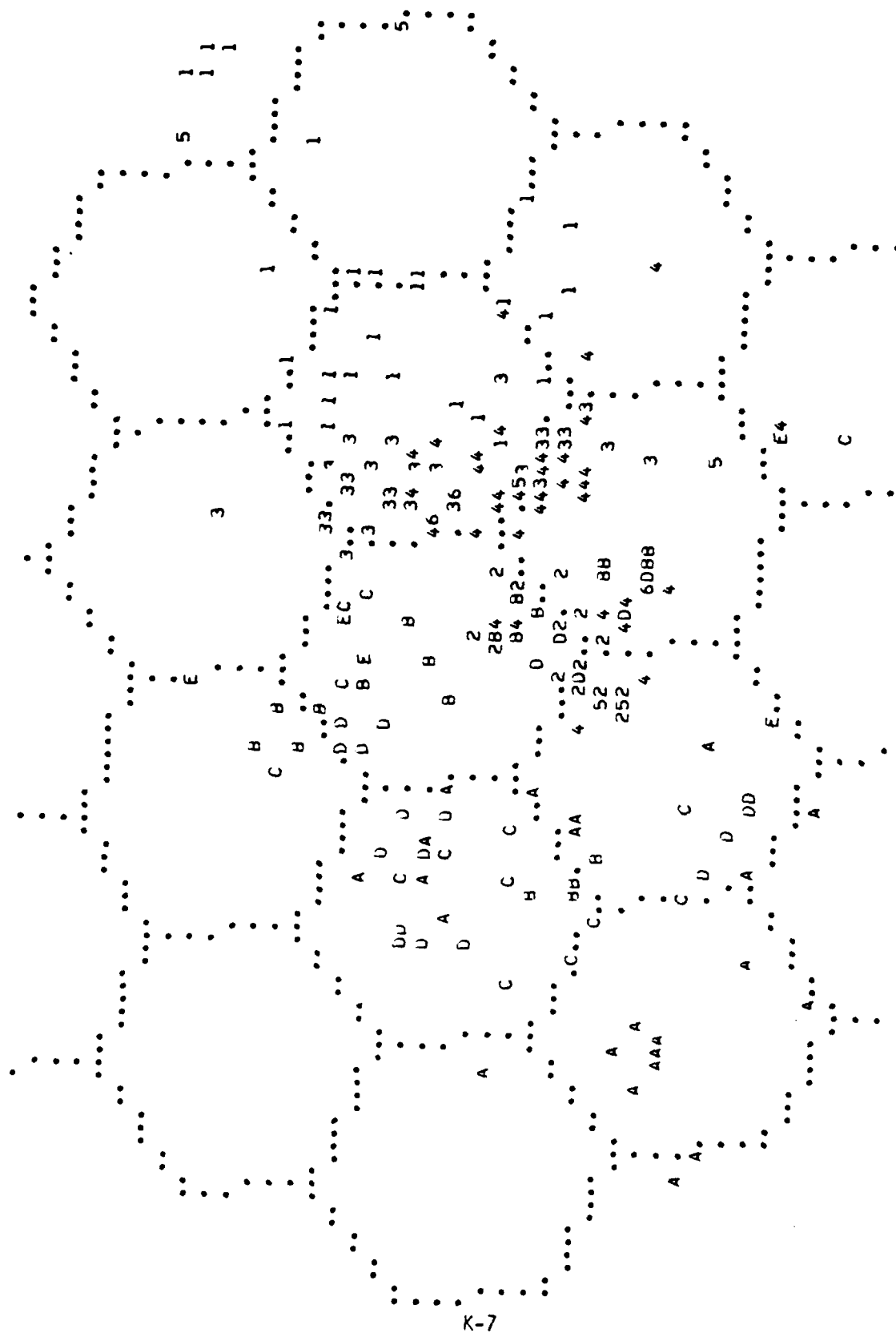


Figure K-6. Case IV-FP unit positions at 02:30 hours.



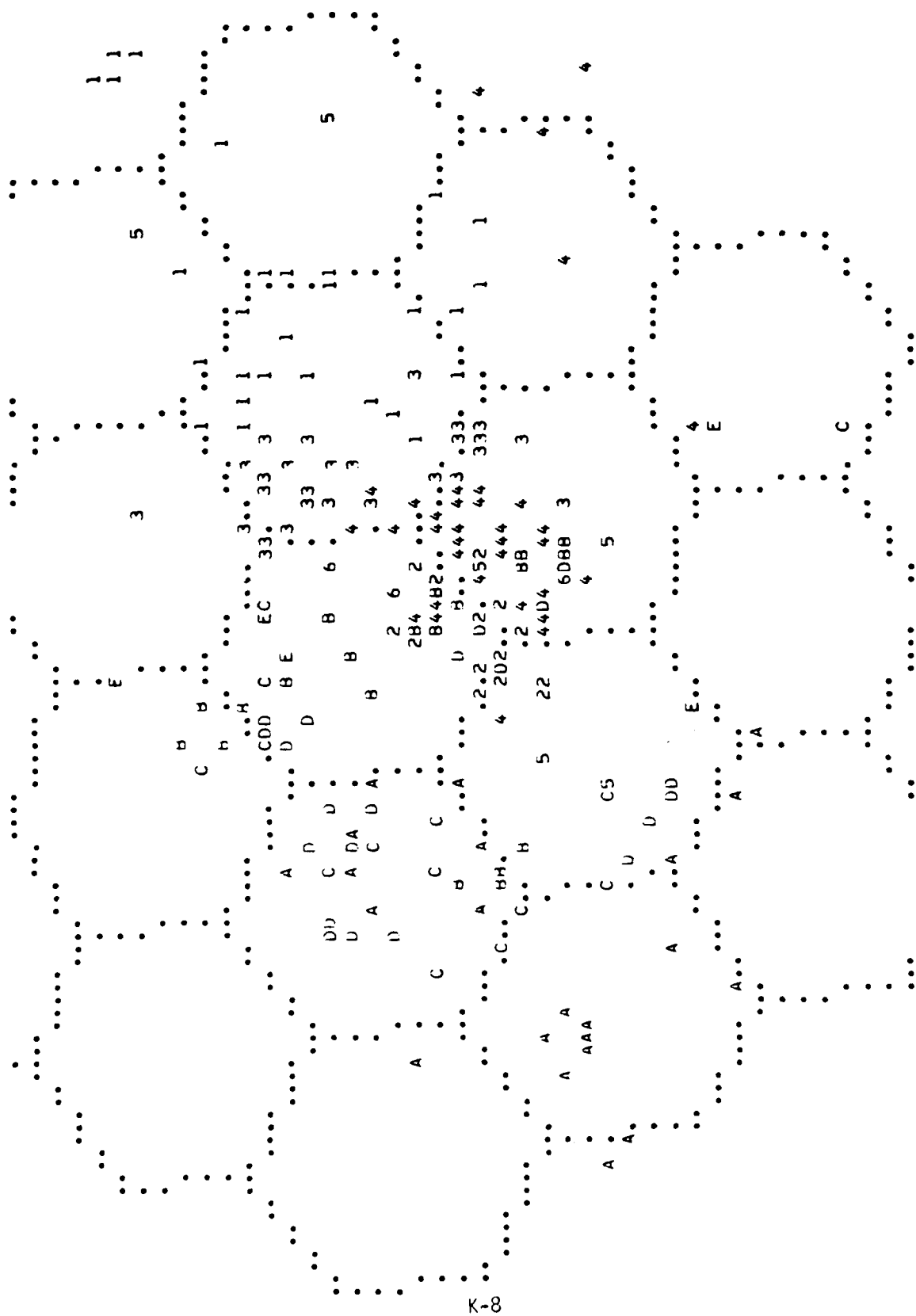


Figure K-7. Case IV-FP unit positions at 03:00 hours.

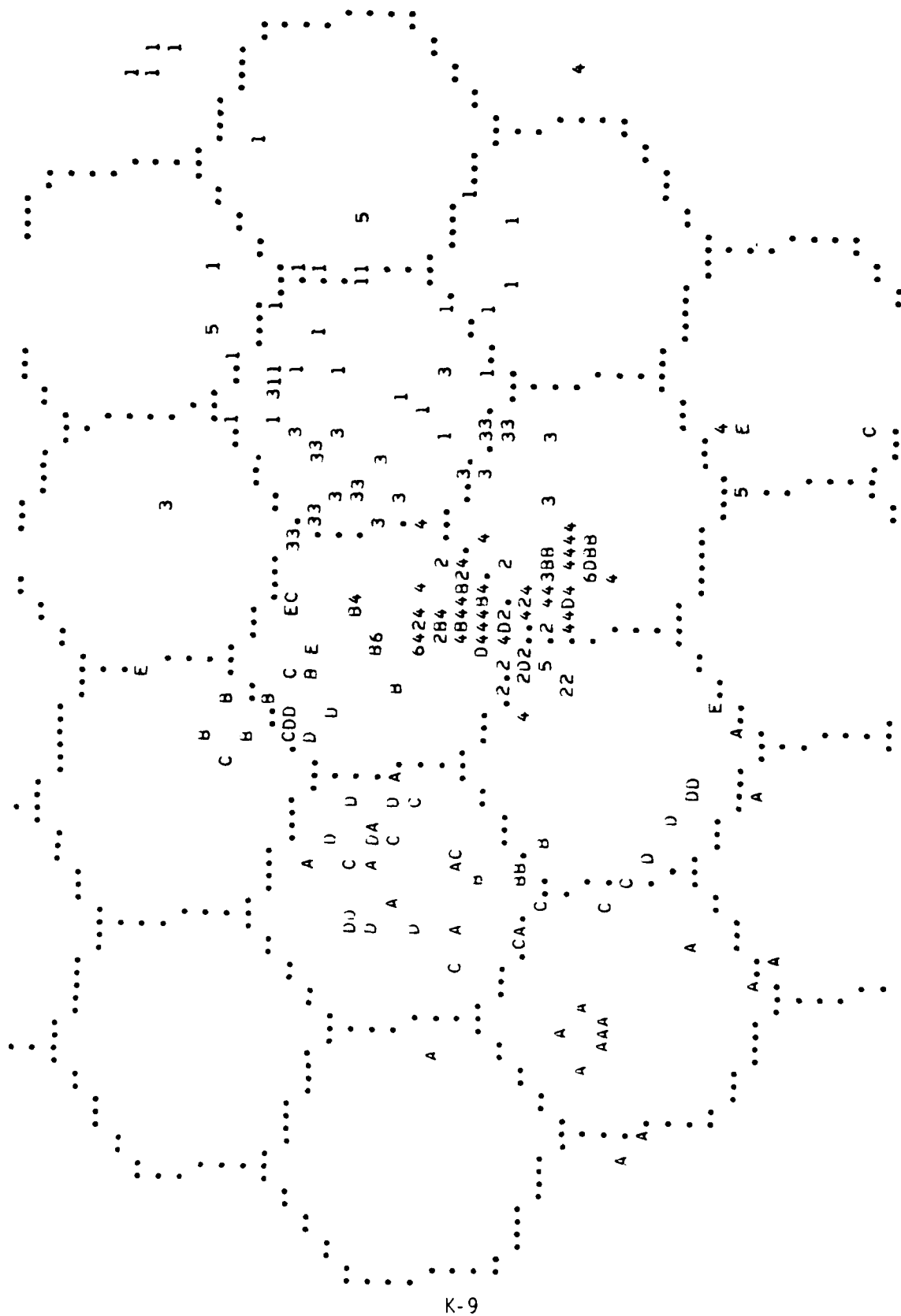


Figure K-8. Case IV-FP unit positions at 03:30 hours.

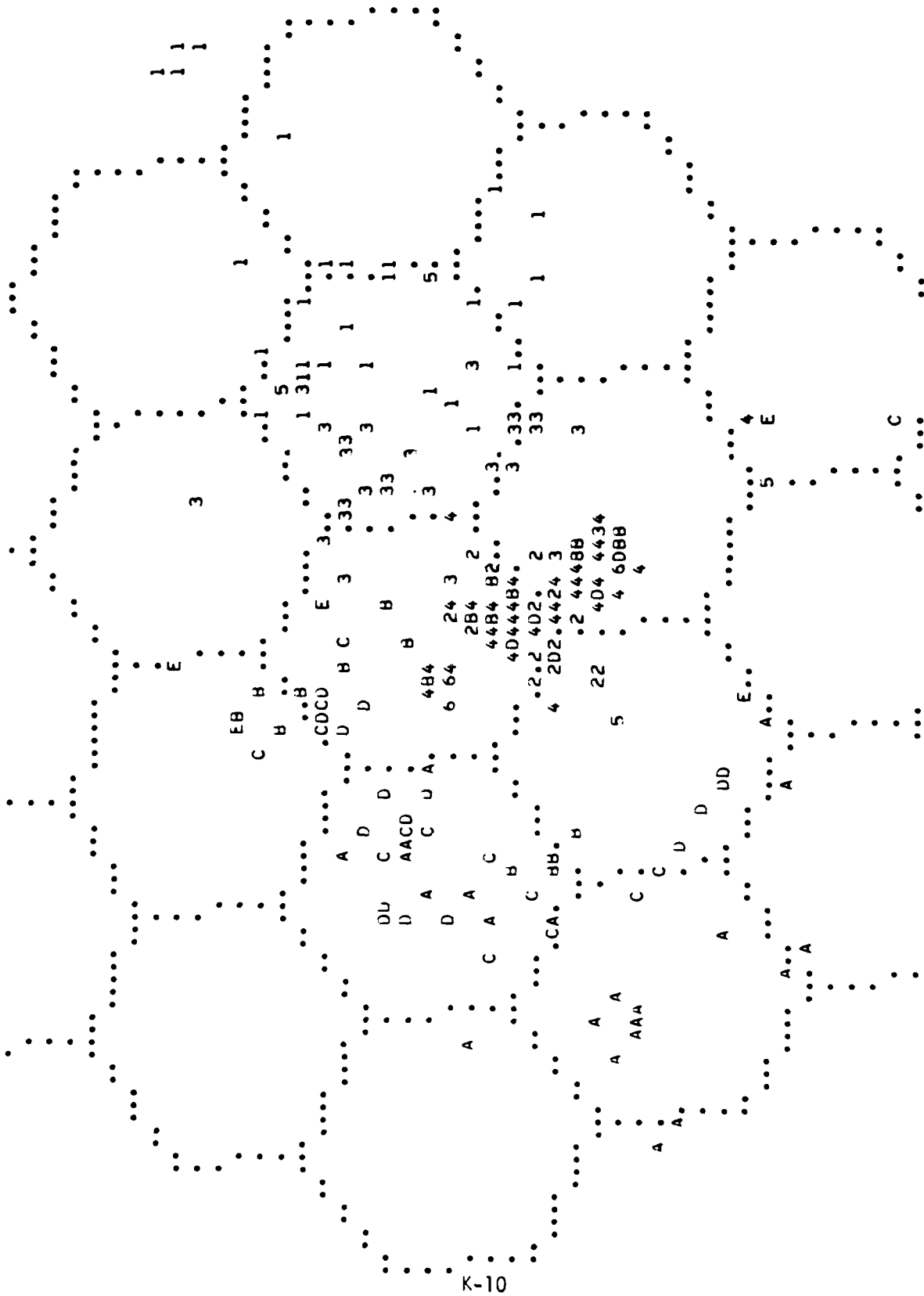


Figure K-9. Case IV-FP unit positions at 04:00 hours.

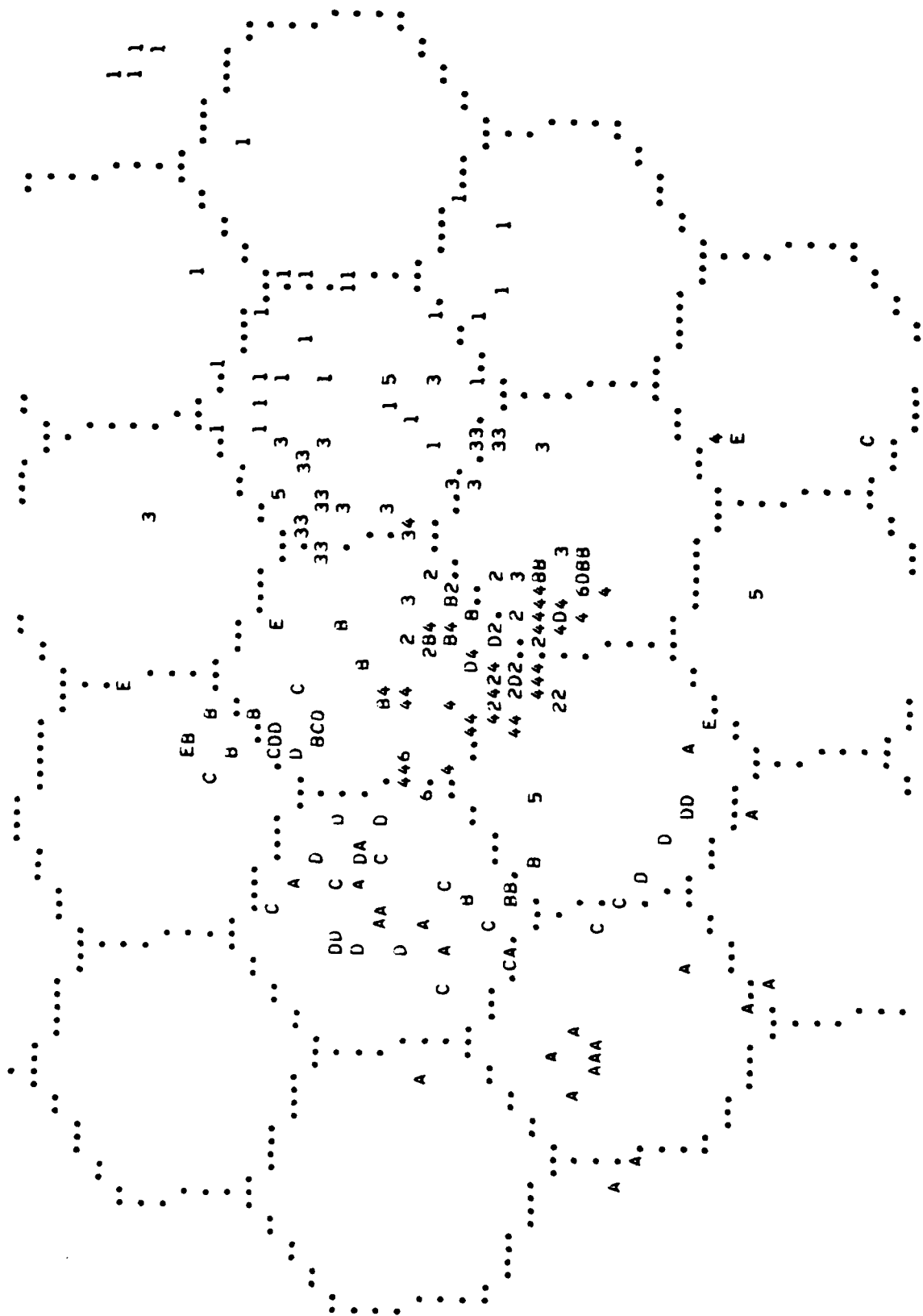


Figure K-10. Case IV-FP unit positions at 04:30 hours.

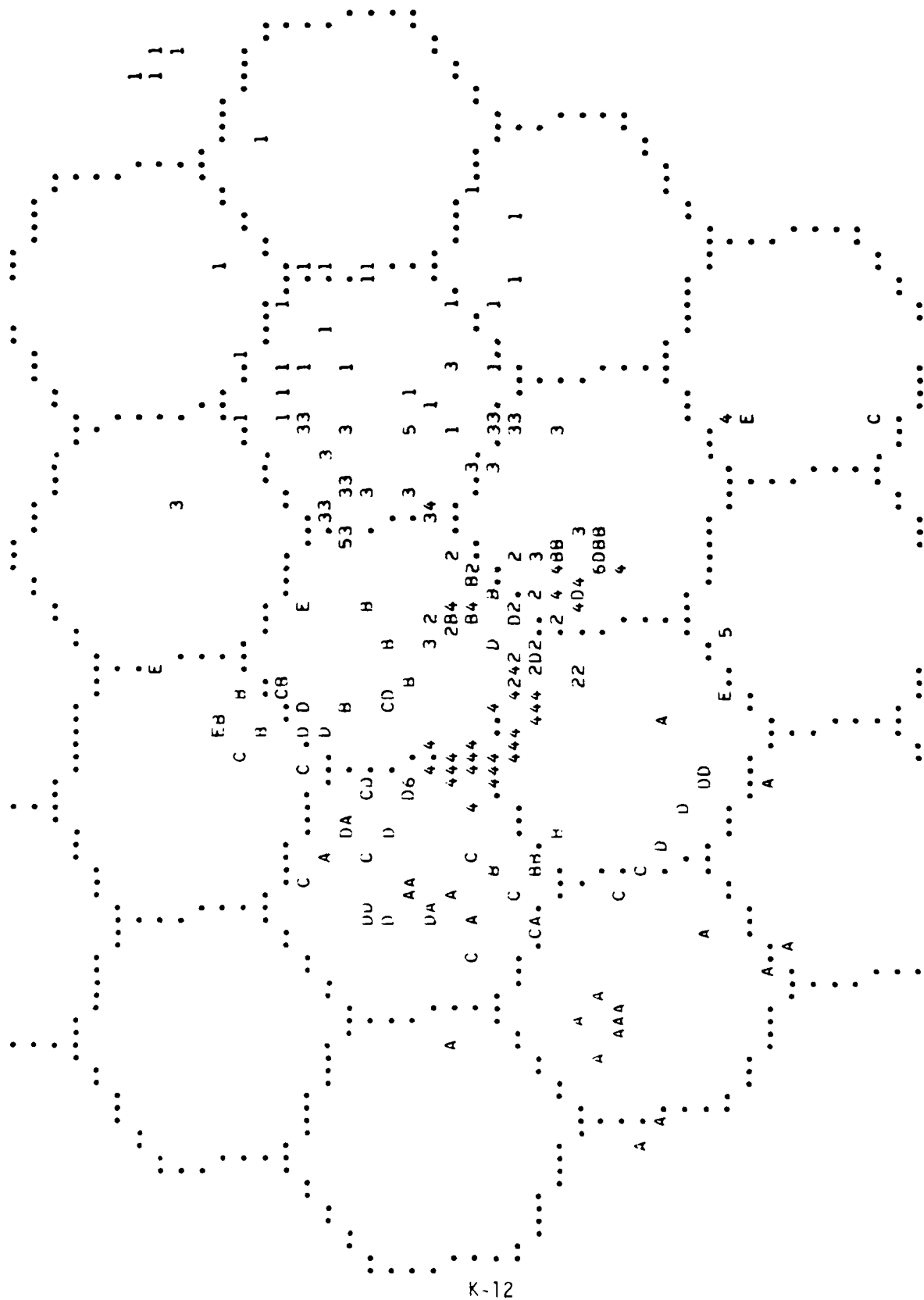
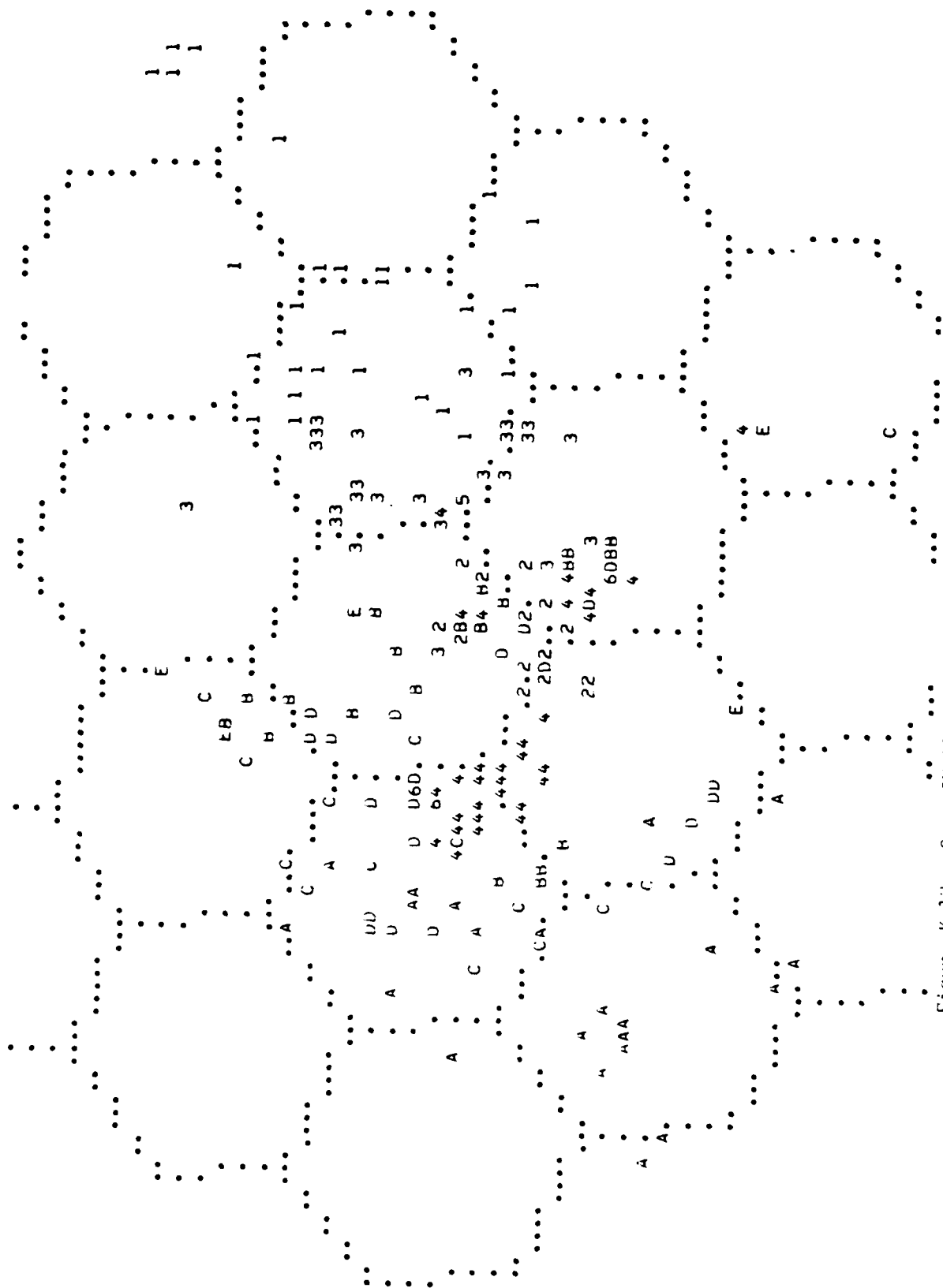


Figure K-11. Case IV-FP unit positions at 05:00 hours.



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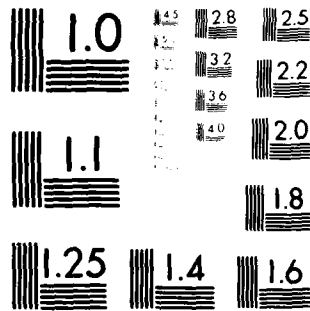
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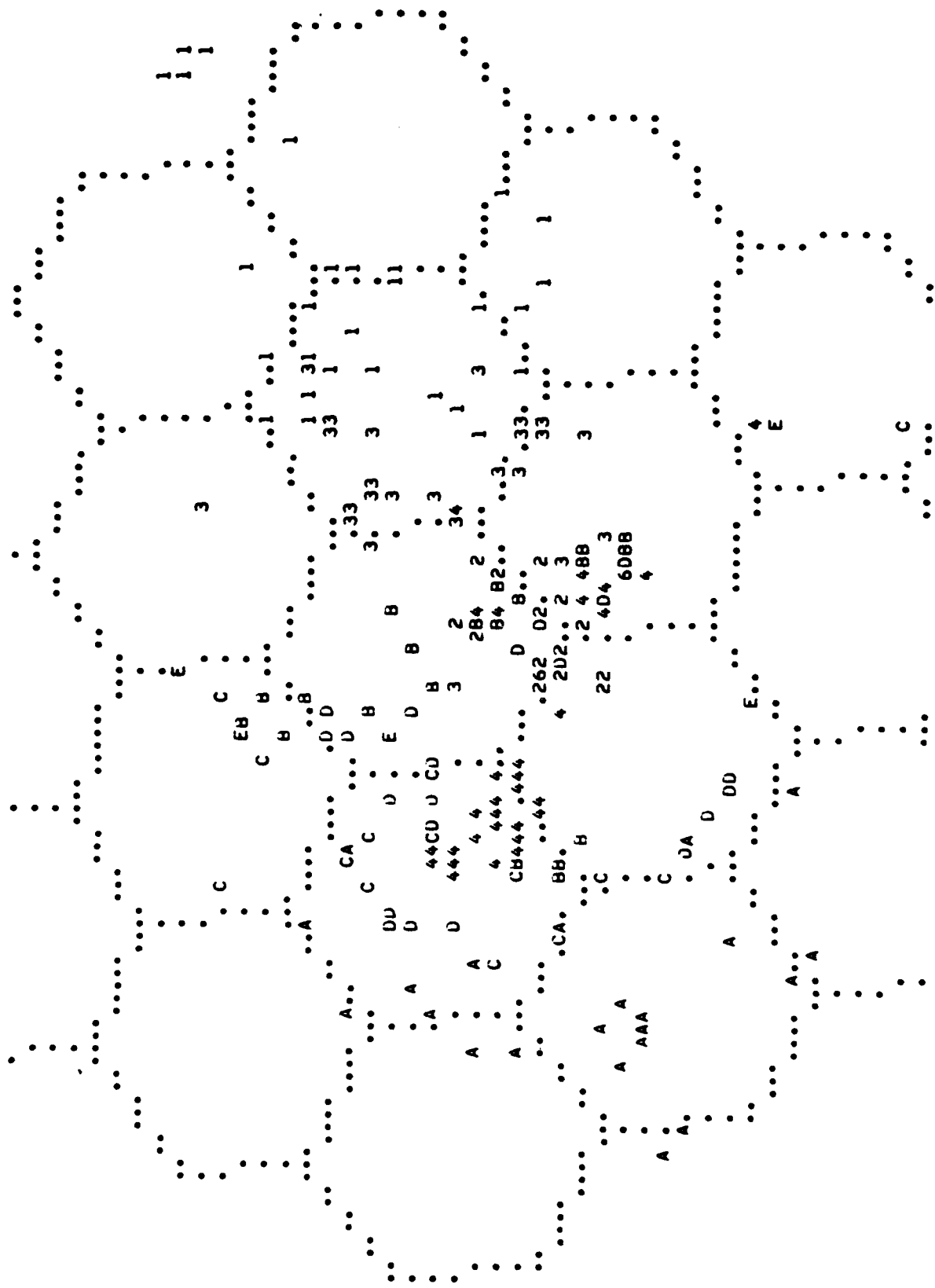


Figure K-13. Case IV-FP unit positions at 06:00 hours.

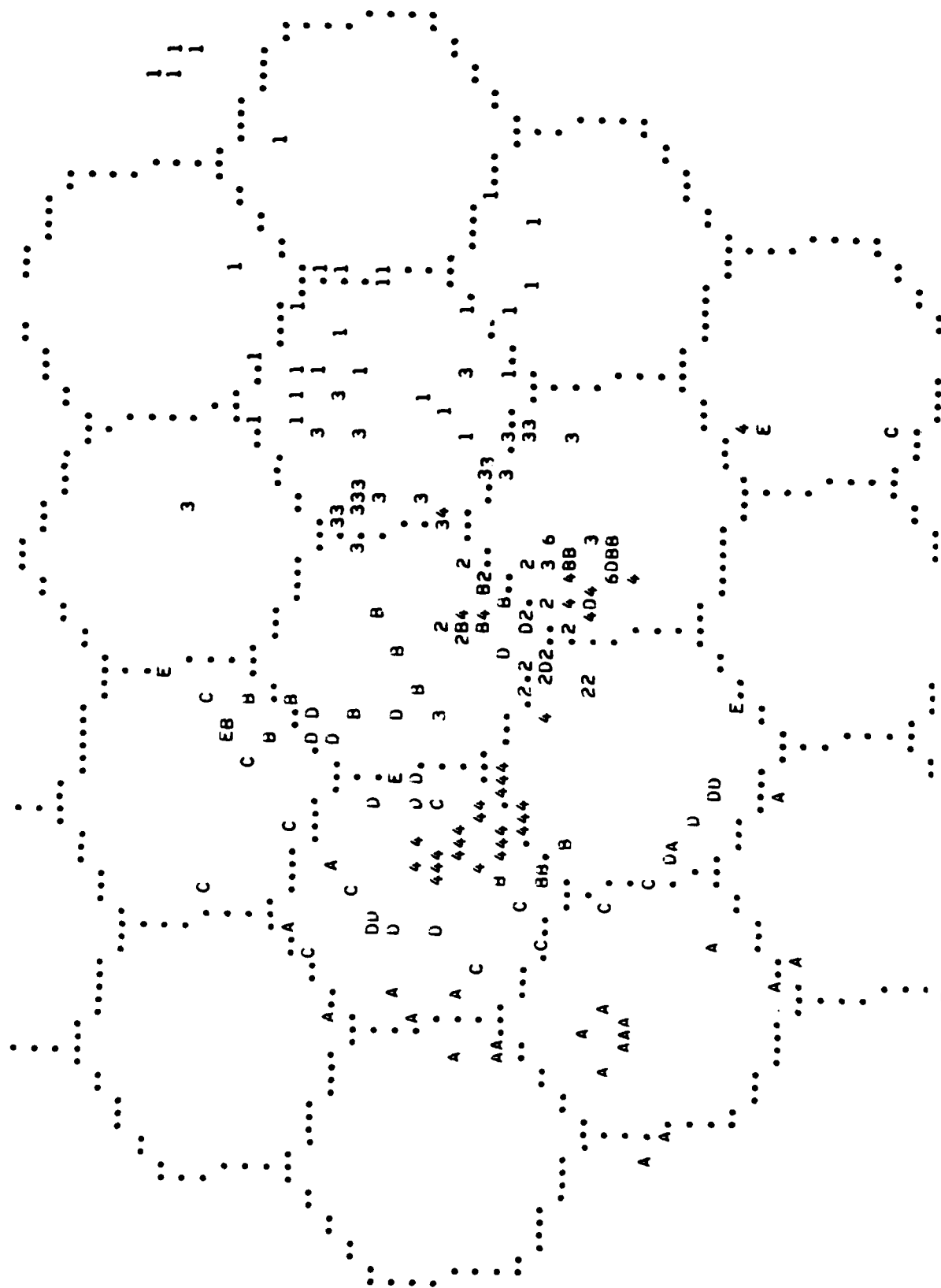


Figure K-14. Case IV-FP unit positions at 06:30 hours.

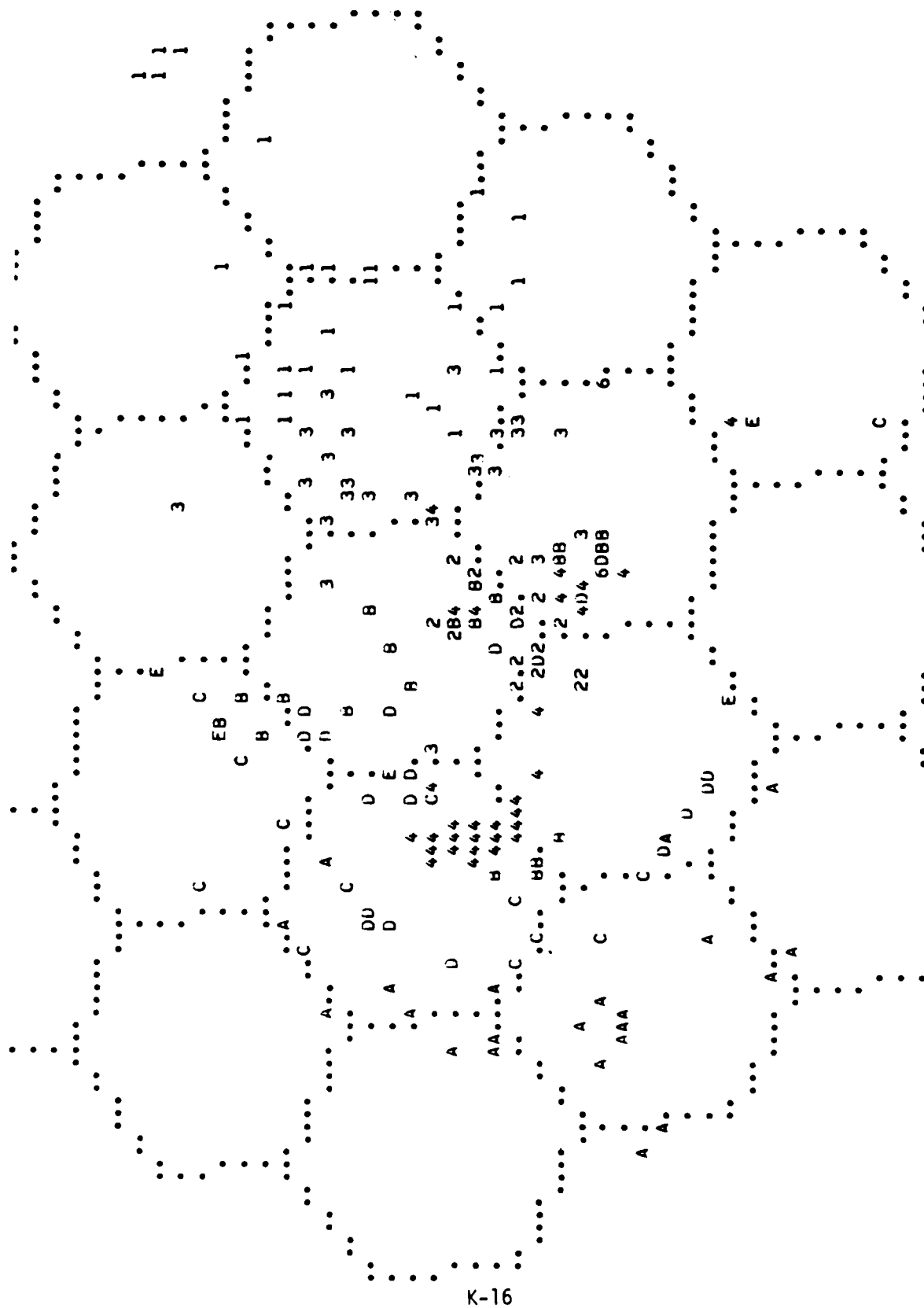


Figure K-15. Case IV-FP unit positions at 07:00 hours.

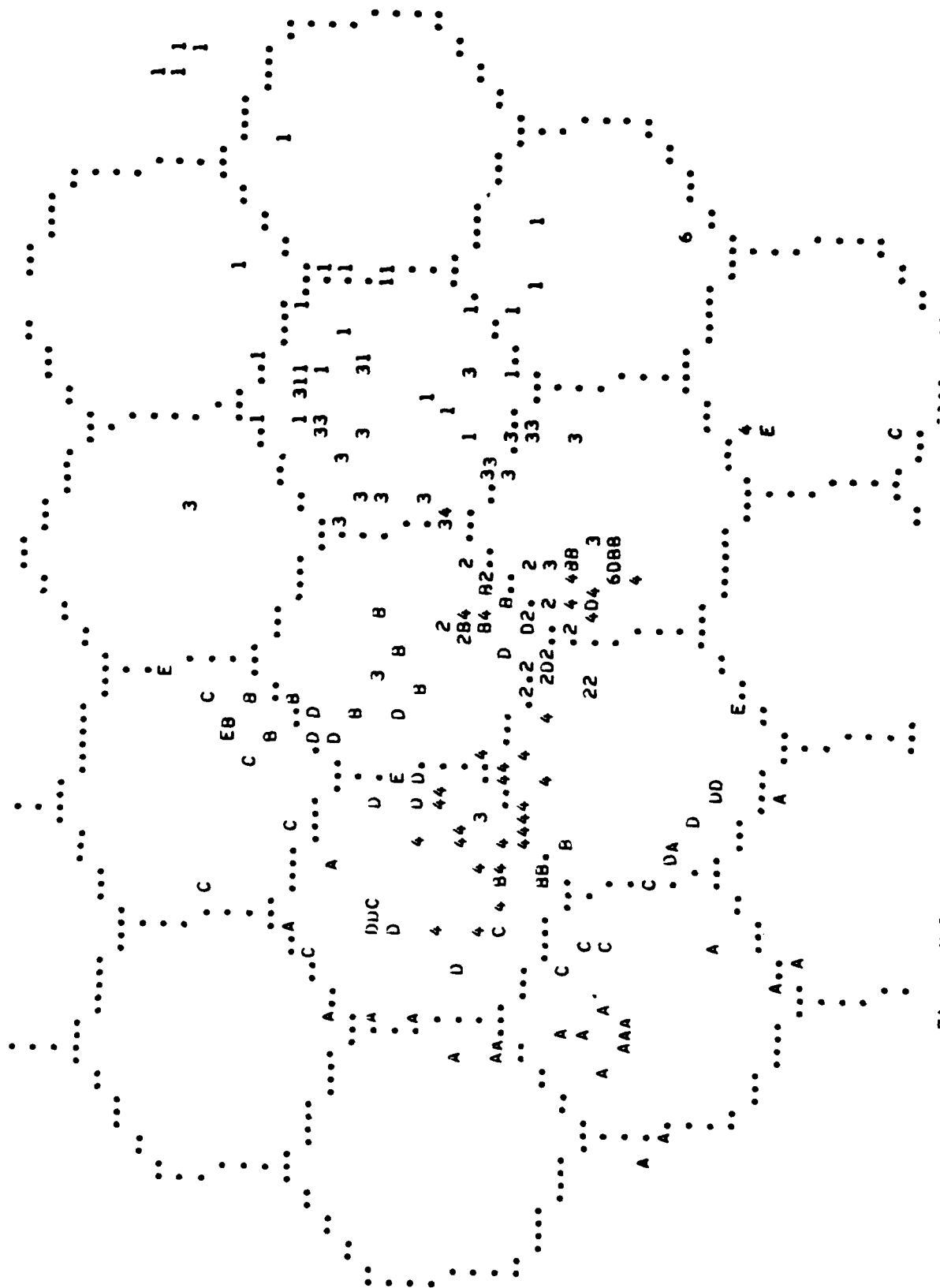


Figure K-16. Case IV-FP unit positions at 07:30 hours.

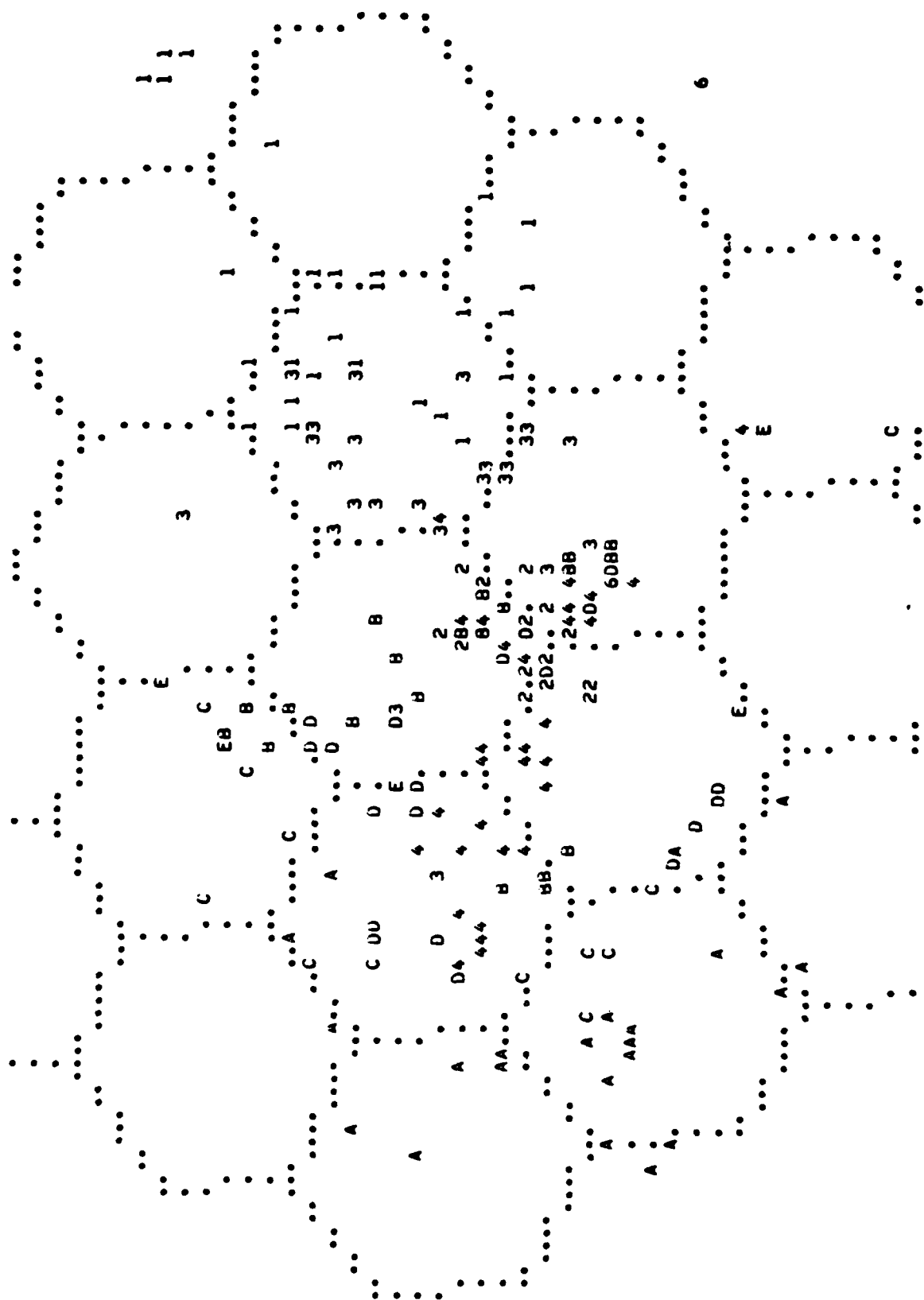


Figure K-17. Case IV-FP unit positions at 08:00 hours.

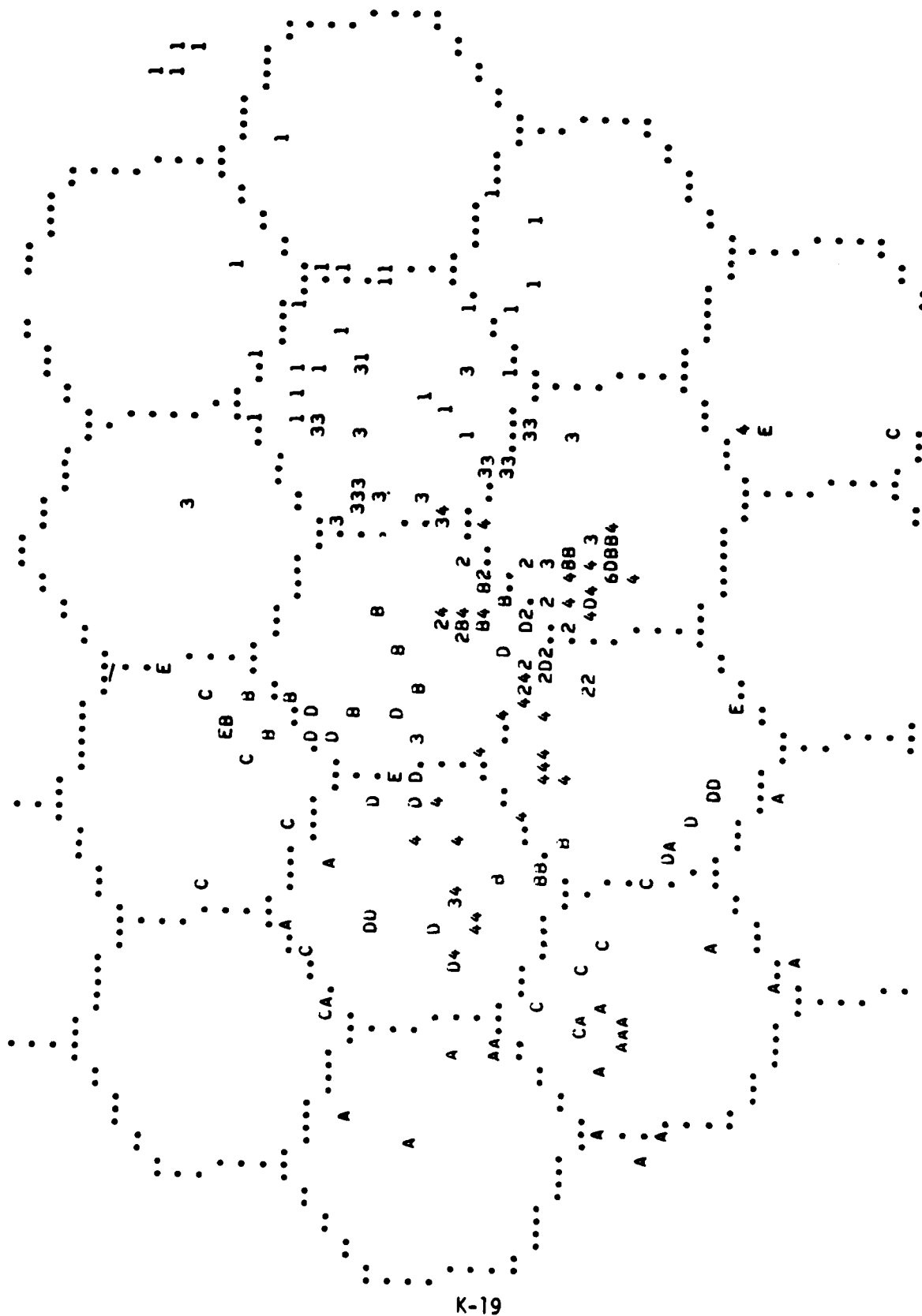


Figure K-18. Case IV-FP unit positions at 08:30 hours.

## APPENDIX L

### GROUND EXCHANGE MAPS

The 19 maps in this appendix were used to obtain a measure of the ground gained (or lost) by the Red advance and penetration of the Blue defenses. For each of the six TRACE cases there are three maps at 02:30, 05:30, and 08:30 hours respectively, and one map (Figure L-1) showing the initial deployment of Red and Blue forces. These maps are duplicates of those found in Appendices F through K.

The initial positions of Red and Blue force units were separated by an arbitrary boundary as shown in Figure L-1. Specific points of the hexagons were chosen to construct this boundary from three straight lines thus allowing precise placement of the same boundary on all other unit position maps. The boundary effectively represents the forward edge of the battle area at the beginning of the conflict.

The curved line on each map encloses the land area occupied by or effectively controlled by Red forces. Although some Blue force units appear within these boundaries, they have been neutralized (but not killed) by the Red forces. The lines were intentionally drawn quite closely to the Red controlling units to assist consistency from map to map. Since it is the relative change between cases that we seek, the exact absolute placement of the lines is not as important as consistent placement. Finally, the area occupied/controlled by the Red forces was determined by direct manual integration of these maps with a planimeter.

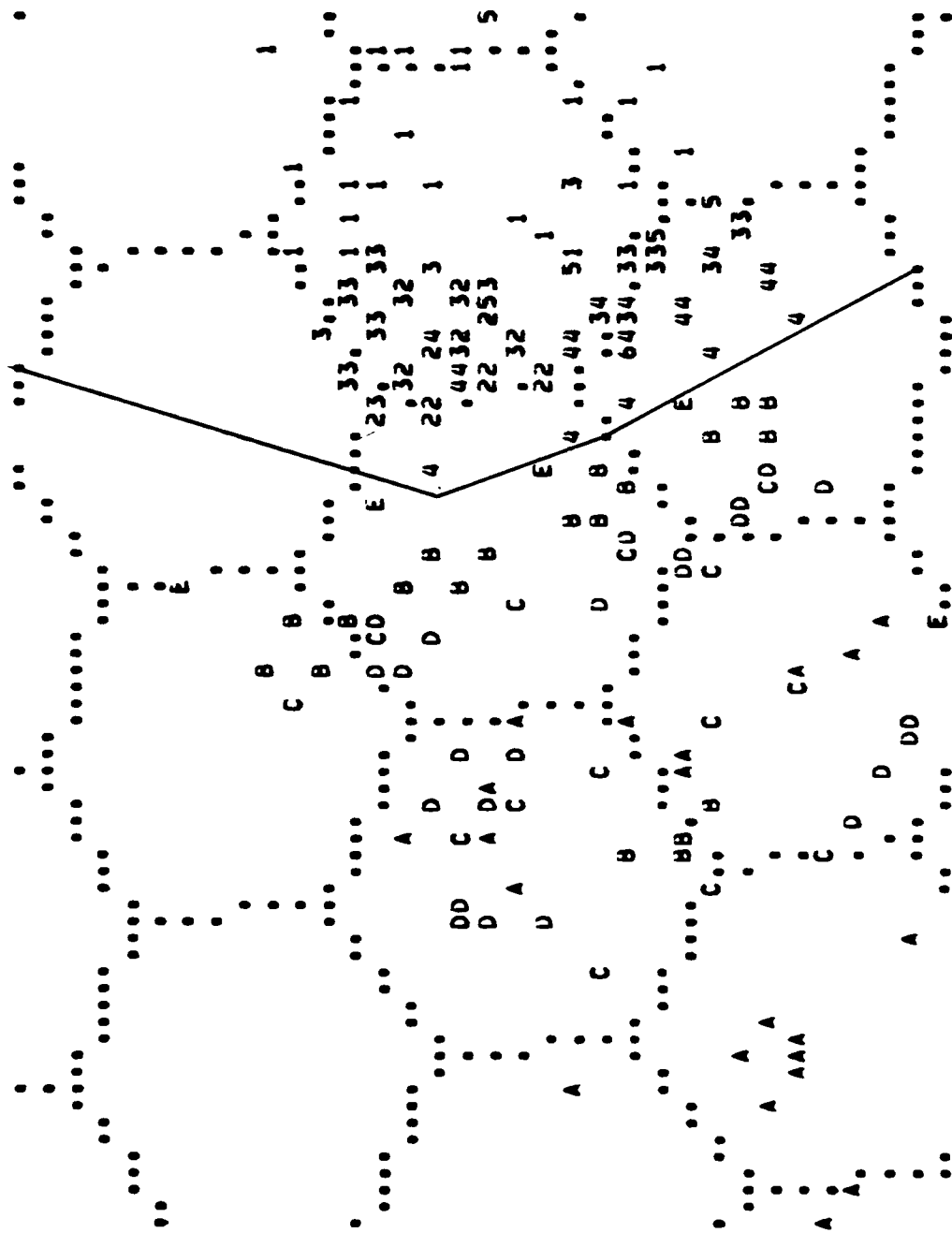


Figure L-1. Initial unit positions and side separation boundary.



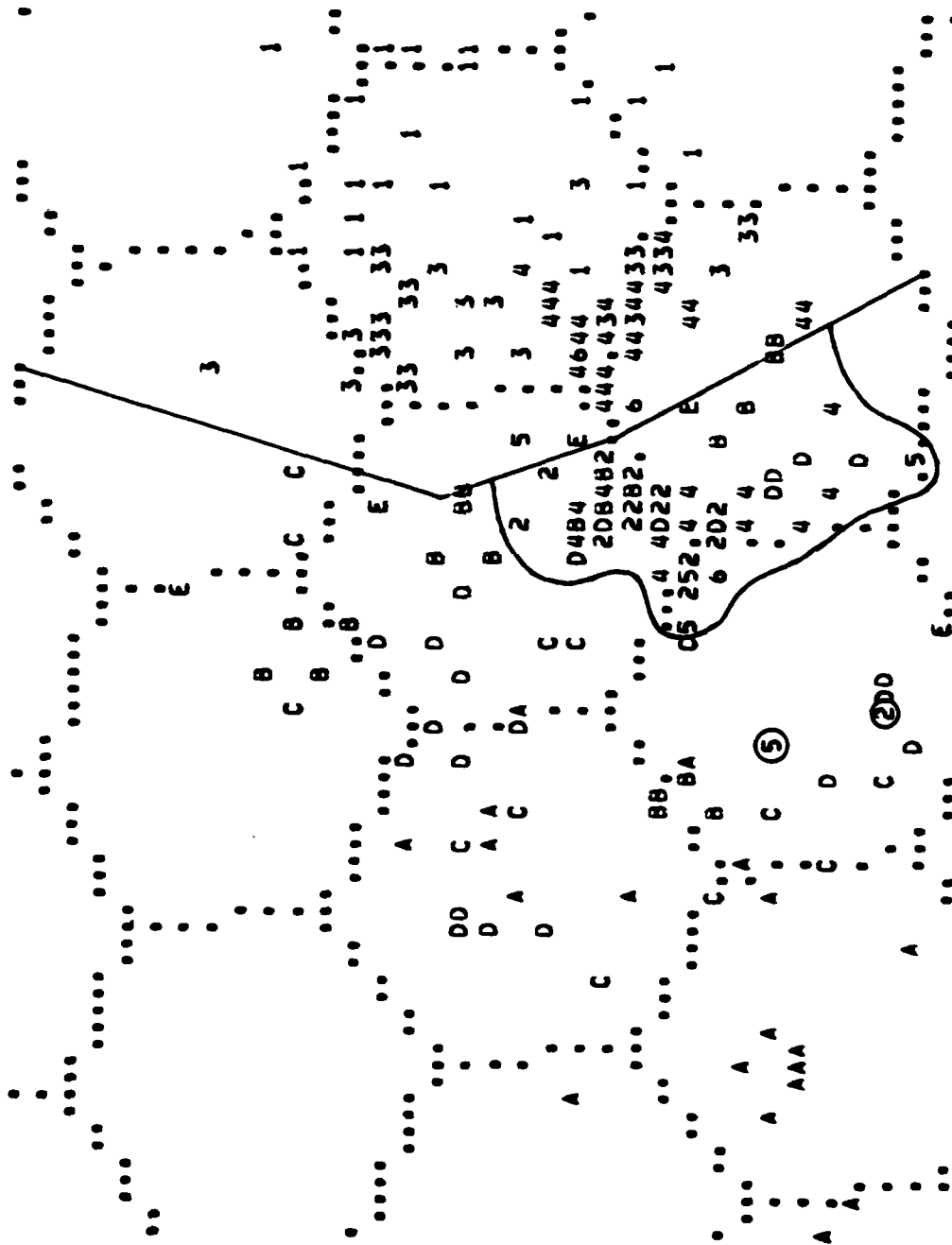


Figure L-2. Case I ground change at 02:30 hours.

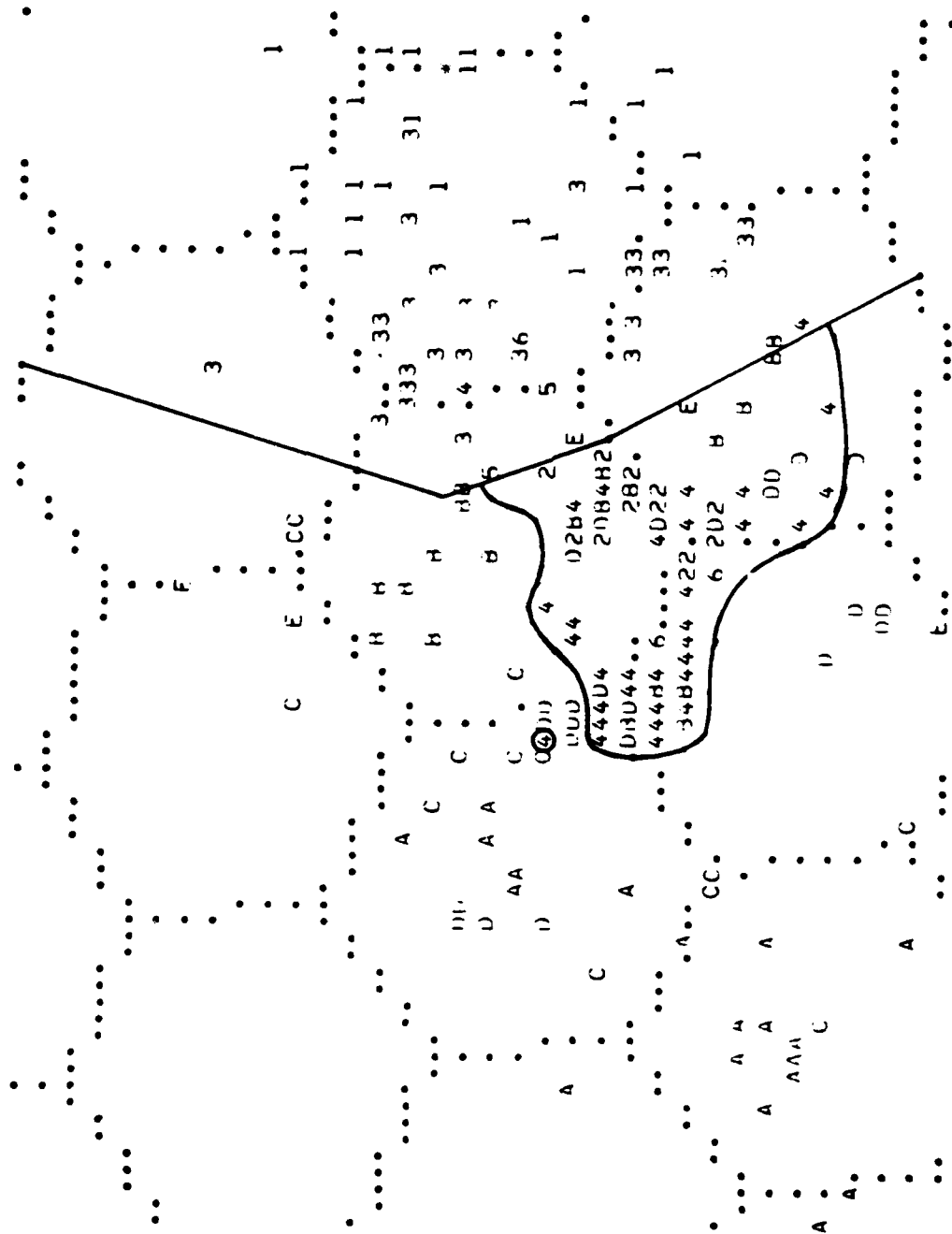
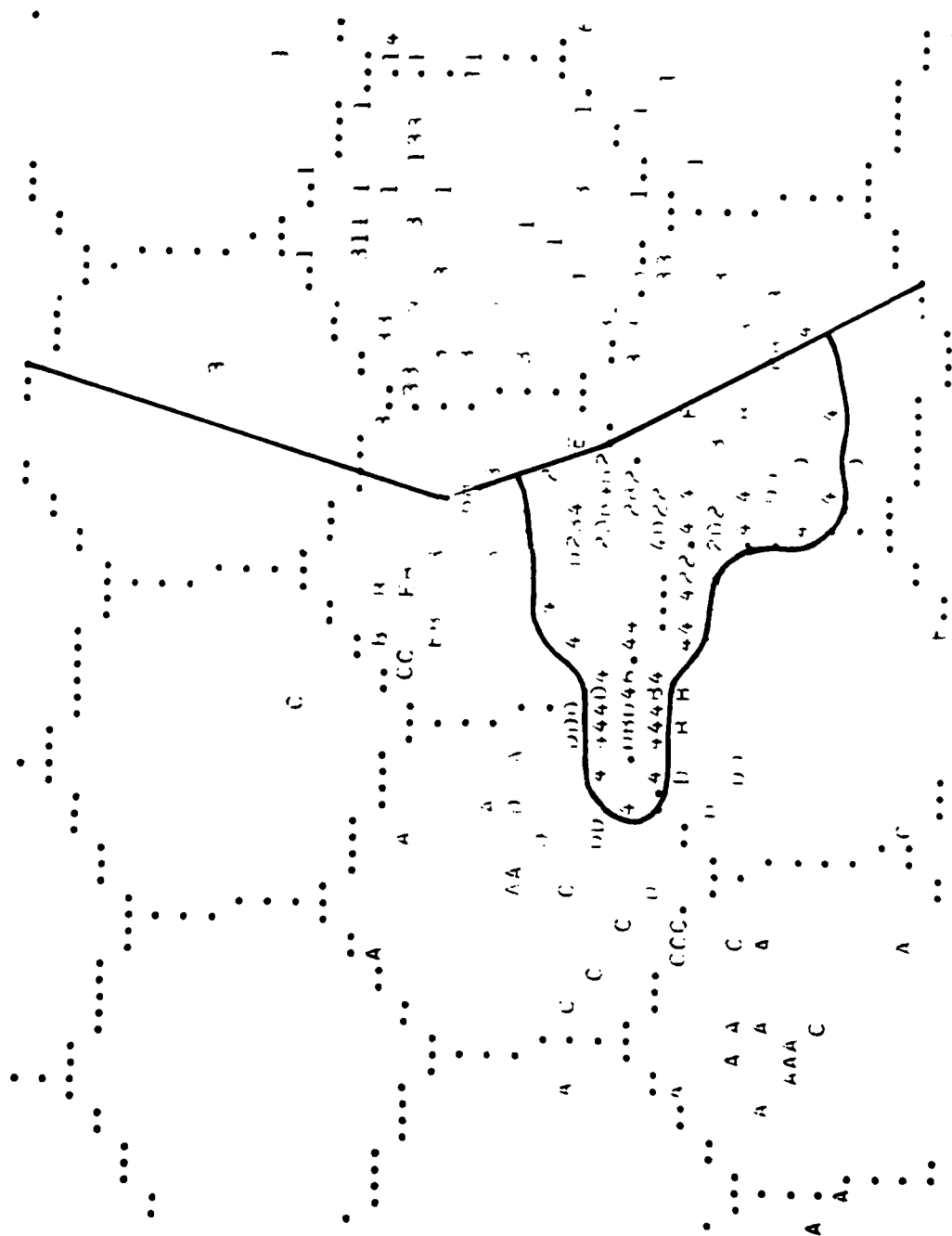


Figure L-3. Case I ground change at 05:30 hours.



**Figure L-4. Case I ground change at 08:30 hours.**

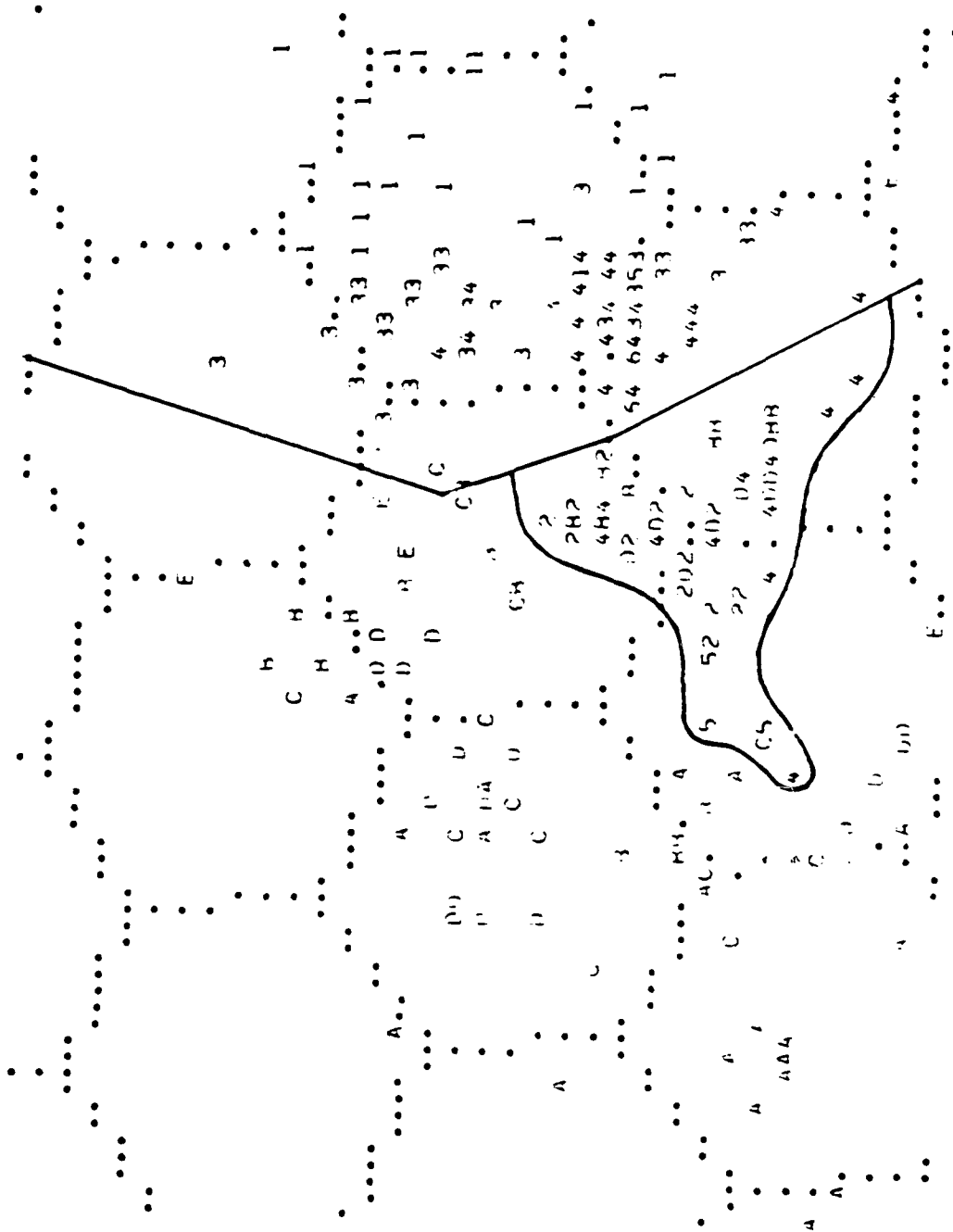


Figure L-5. Case II ground change at 02:30 hours.

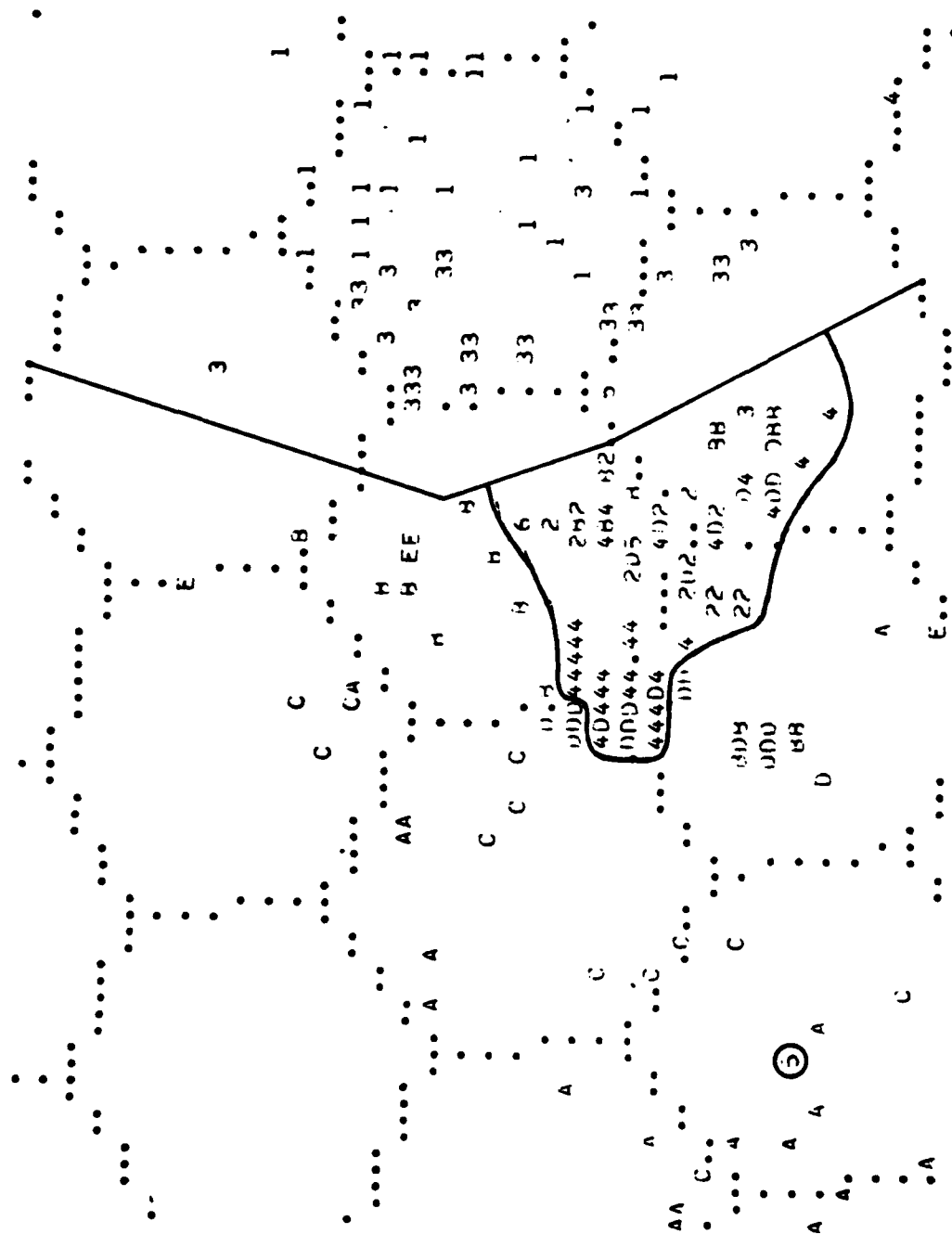


Figure L-6. Case II ground change at 05:30 hours.

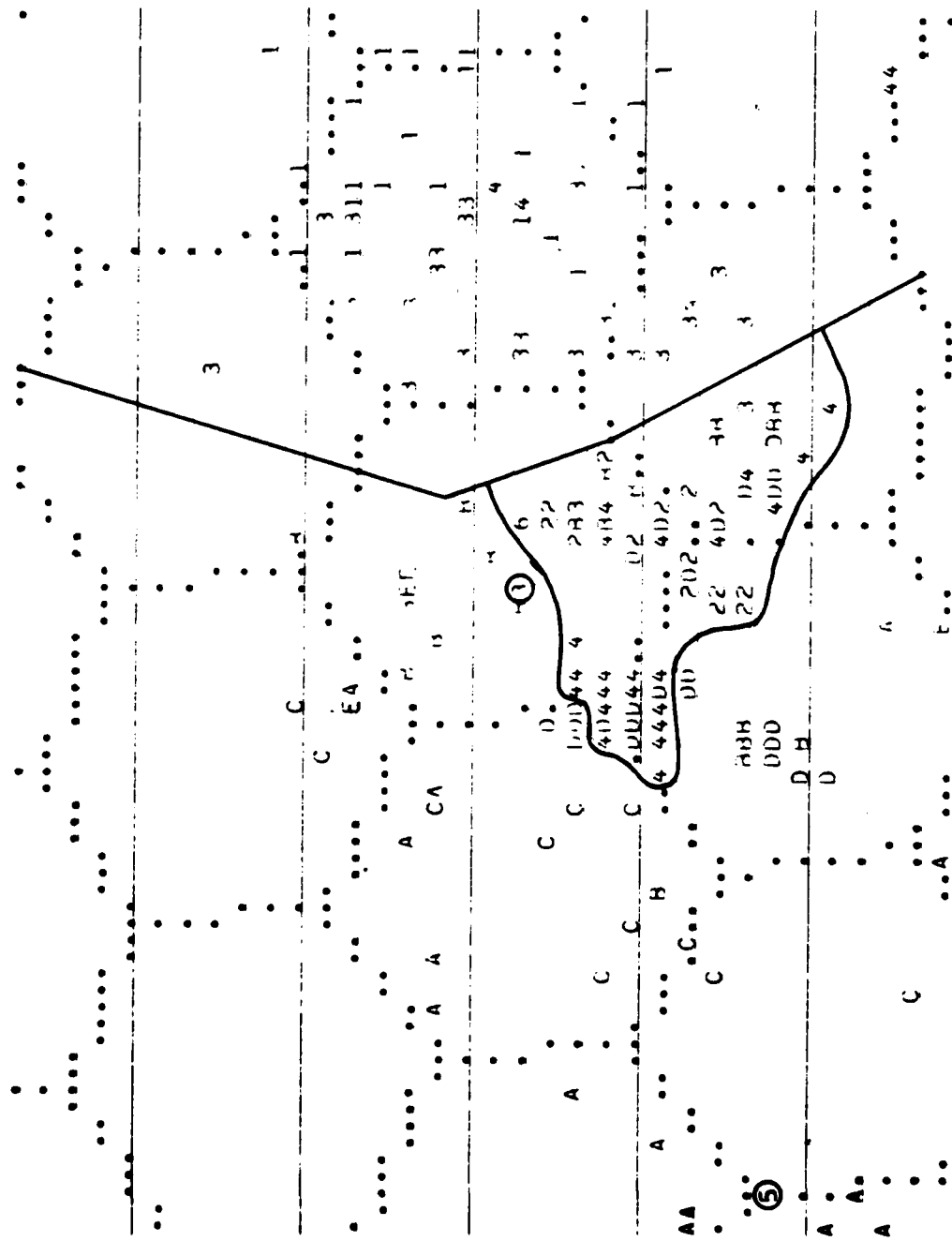


Figure L-7. Case II ground change at 08:30 hours.

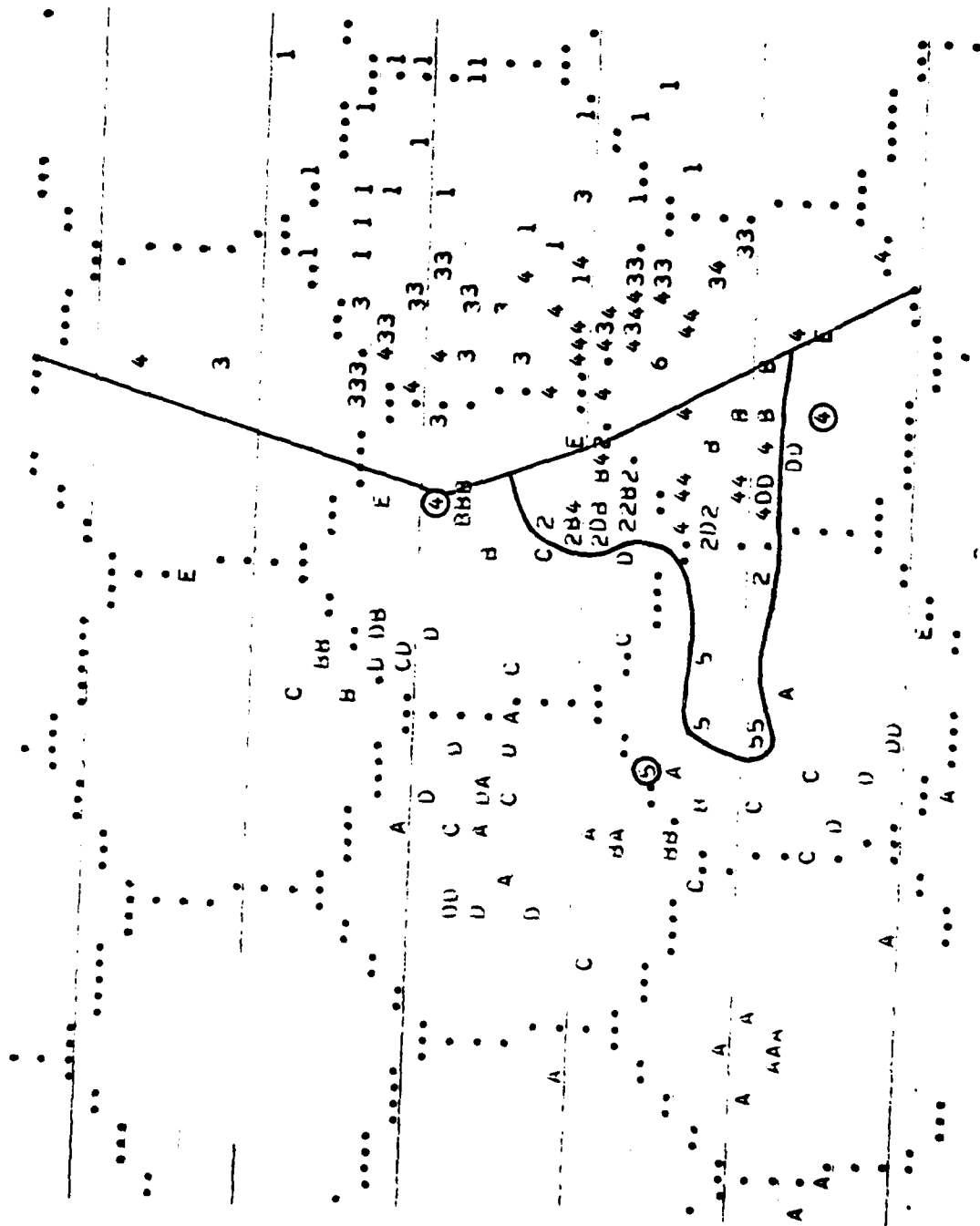
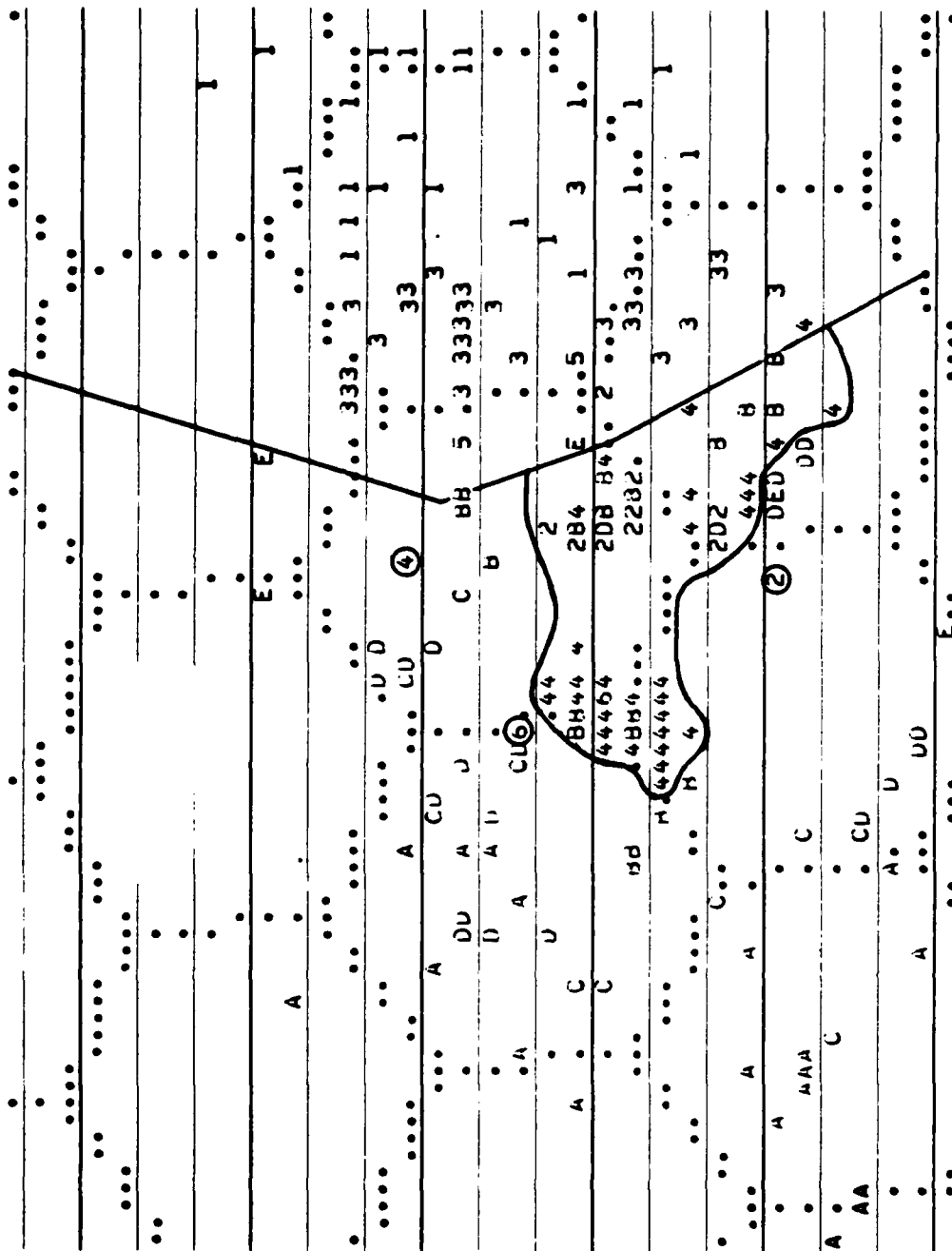


Figure L-8. Case III ground change at 02:30 hours.



**Figure L-9. Case III ground change at 05:30 hours.**





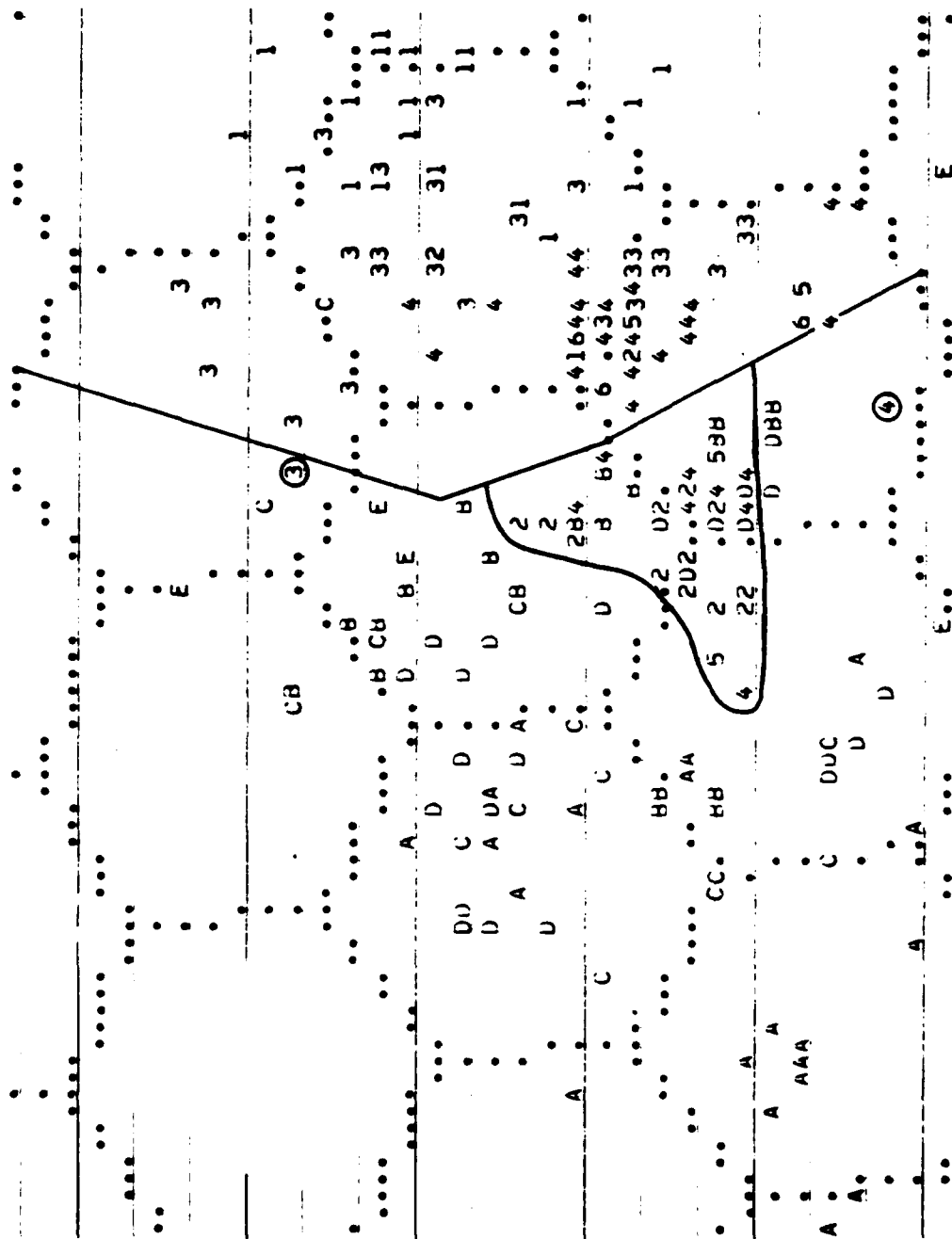


Figure L-11. Case IV ground change at 02:30 hours.



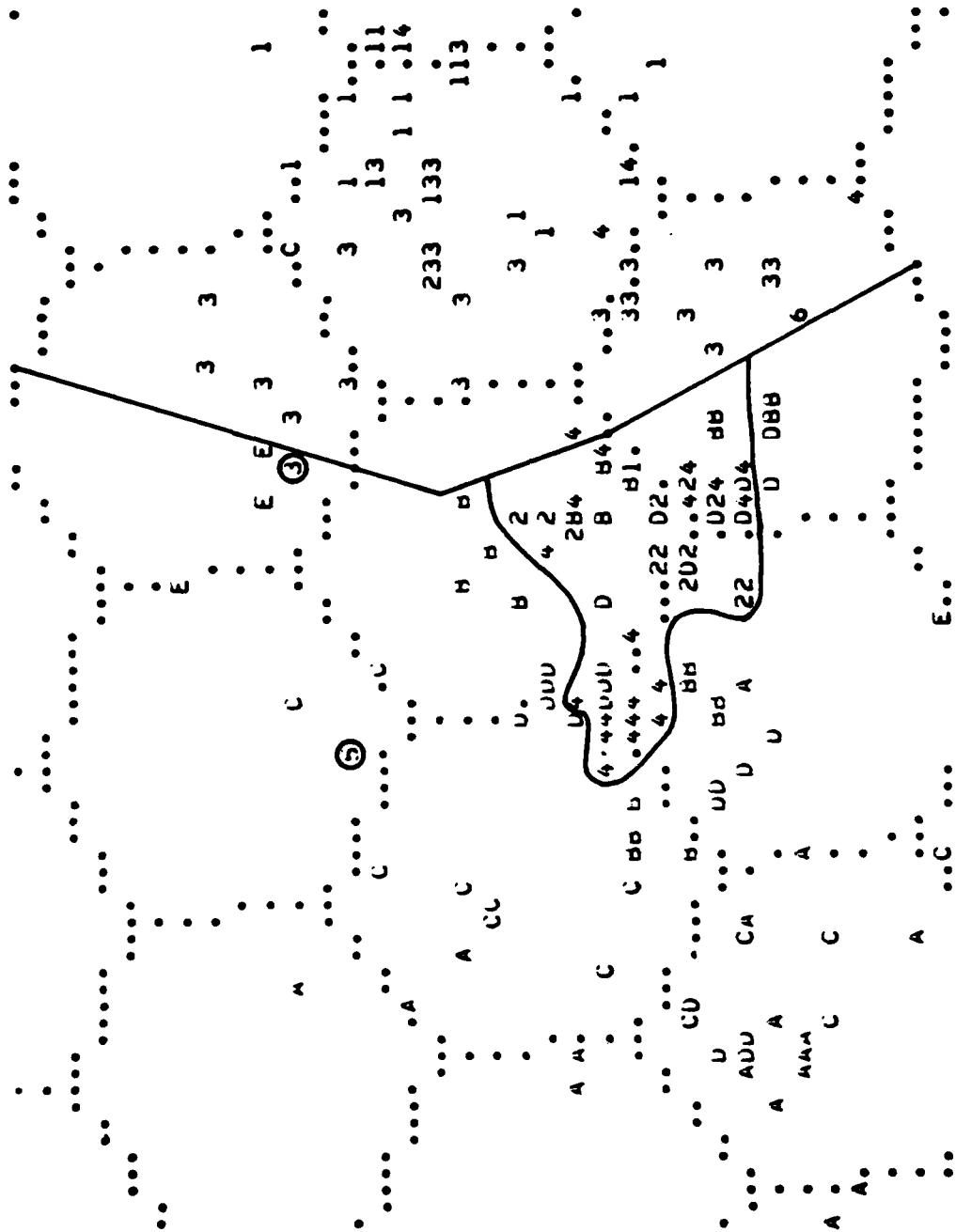


Figure L-13. Case IV ground change at 08:30 hours.

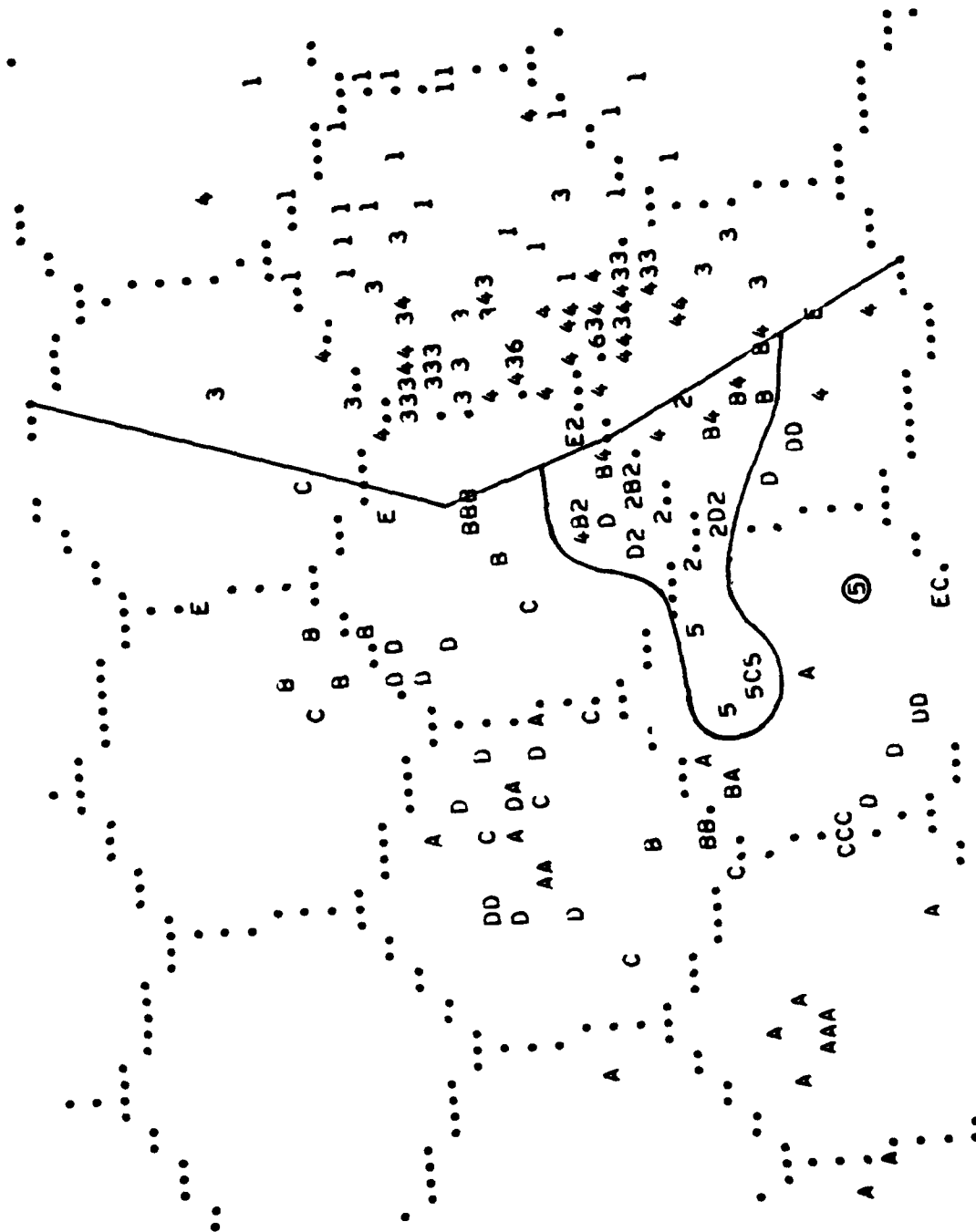


Figure L-14. Case 111-FP ground change at 02:30 hours.

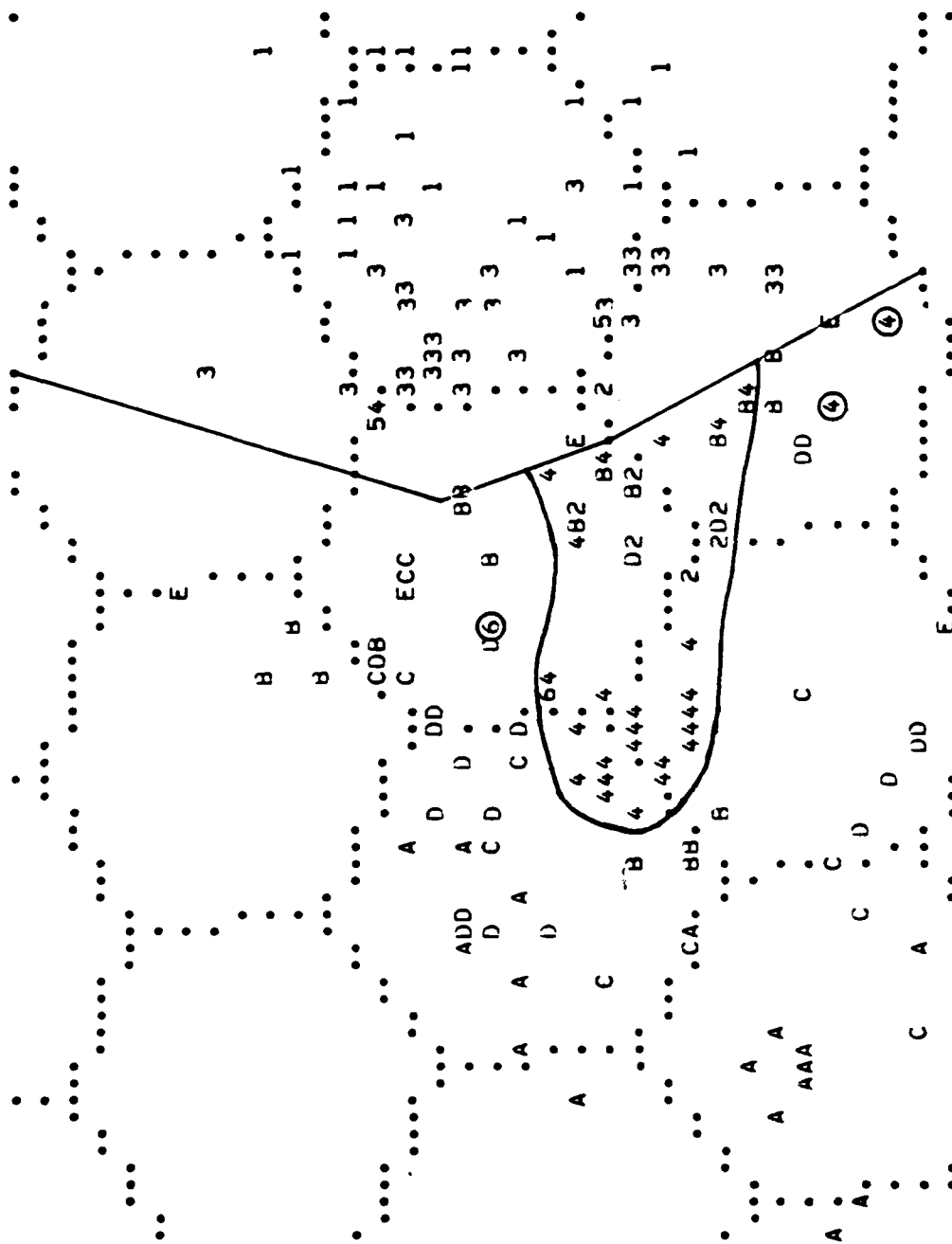


Figure L-15. Case III-FP ground change at 05:30 hours.



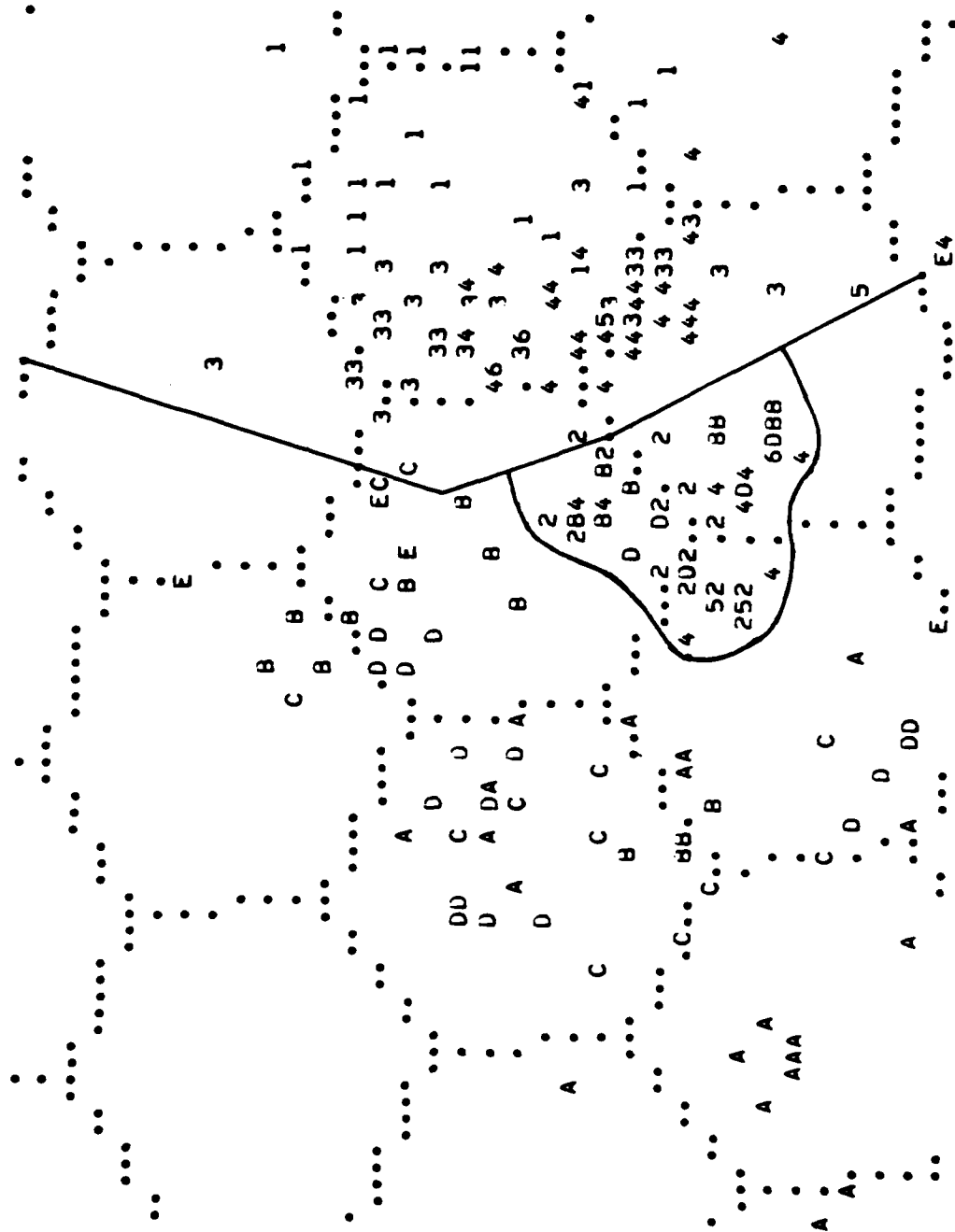


Figure L-17. Case IV-FP ground change at 02:30 hours.



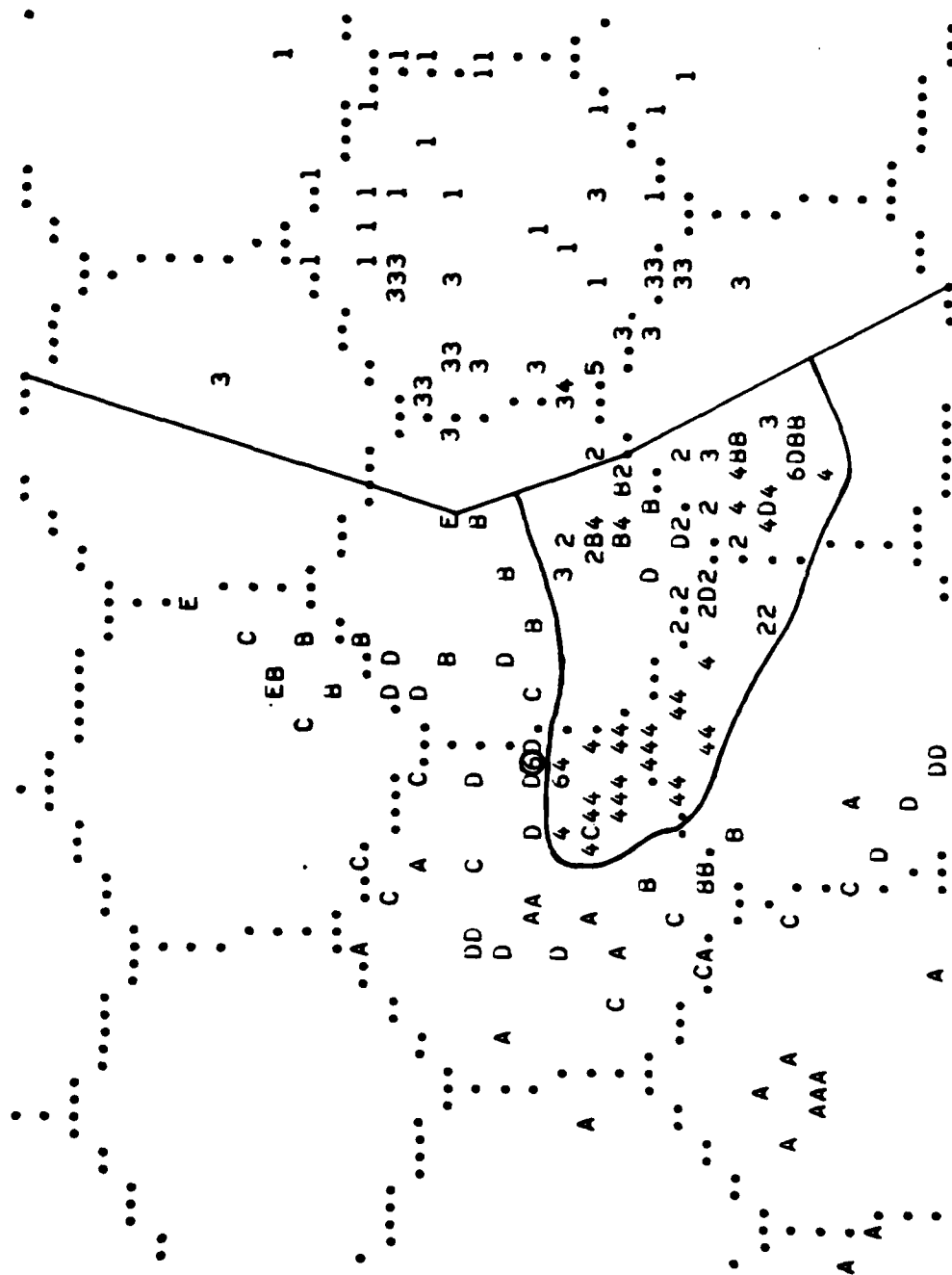


Figure L-18. Case IV-FP ground change at 05:30 hours.



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ATTN: DCSOPS-AEAGC-DSW  
ATTN: ODCSE-E AEAGE  
ATTN: DCSOPS-AEAGC-O  
ATTN: DCSOPS-AEAGB  
ATTN: DCSOPS-AEAGD-MM

U.S. Army Materiel Sys. Analysis Activity  
ATTN: DRXSY-S  
ATTN: DRXSY-DS

U.S. Army Missile Command  
ATTN: DRSMI-YDR

U.S. Army Nuclear & Chemical Agency  
ATTN: Library

U.S. Army Satellite Comm. Agency  
ATTN: TACSAT Office  
ATTN: DRCPM-SC-11

U.S. Army TRADOC Systems Analysis Activity  
ATTN: ATAA-TAC

U.S. Army Training and Doctrine Comd.  
ATTN: Technical Library  
ATTN: ATCD-Z

U.S. Army War College  
ATTN: Library

V Corps  
Department of the Army  
ATTN: AETVGC  
ATTN: AETVGB  
ATTN: AETVCE

VII Corps  
Department of the Army  
ATTN: AETSGB-O  
ATTN: AETSCE  
ATTN: AETSGC

DEPARTMENT OF THE NAVY

Command & Control Programs  
Department of the Navy  
ATTN: OP 941

Naval Ocean Systems Center  
ATTN: Research Library

Naval Surface Weapons Center  
ATTN: Code F31

Office of the Chief of Naval Operations  
ATTN: OP 94  
ATTN: OP 604 E/F  
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DEPARTMENT OF THE NAVY (Continued)

Commander-in-Chief  
U.S. Atlantic Fleet  
Department of the Navy  
ATTN: Doce J-611A  
ATTN: Code J54

Commander-in-Chief  
U.S. Naval Forces, Europe  
ATTN: N3262, Nuclear Surety Officer

DEPARTMENT OF THE AIR FORCE

Air Force Geophysics Laboratory  
ATTN: SULL

Air Force Weapons Laboratory  
Air Force Systems Command  
ATTN: SUL  
ATTN: DYC

Assistant Chief of Staff, Intelligence  
Department of the Air Force  
ATTN: INK

Assistant Chief of Staff  
Studies & Analyses  
Department of the Air Force  
ATTN: AF/SASC  
ATTN: AF/SAGF

Deputy Chief of Staff  
Operations Plans and Readiness  
Department of the Air Force  
ATTN: AFXOK  
ATTN: AFXOXM

Deputy Chief of Staff  
Research, Development & Acq  
Department of the Air Force  
ATTN: AFRDQSM

Electronic Systems Division  
Department of the Air Force  
ATTN: XRC

Foreign Technology Division  
Air Force Systems Command  
ATTN: NIIS Library

Headquarters Space Division  
Air Force Systems Command  
ATTN: SKA

Headquarters Space Division  
Air Force Systems Command  
ATTN: YCPC

Strategic Air Command  
Department of the Air Force  
ATTN: NRT  
ATTN: XPFS  
ATTN: DCXT

Tactical Air Command  
Department of the Air Force  
ATTN: DRA

DEPARTMENT OF THE AIR FORCE (Continued)

Commander in Chief  
U.S. Air Forces in Europe  
ATTN: DOC  
ATTN: XPXX

OTHER GOVERNMENT AGENCY

Central Intelligence Agency  
ATTN: OSR/SF, R. Virgo  
ATTN: OSR/SEC  
ATTN: OSI/LSD, R. Hart

DEPARTMENT OF DEFENSE CONTRACTORS

BDM Corp.  
ATTN: W. Sweeney  
ATTN: Corporate Library

Commander  
66th MI Group  
ATTN: RDA/Munich

Computer Sciences Corp.  
ATTN: H. Blank  
ATTN: Library

ESL, Inc.  
ATTN: J. Marshall  
ATTN: Library

General Electric Company-TEMPO  
ATTN: DASIAc

General Electric Company-TEMPO  
ATTN: DASIAc

GTE Sylvania, Inc.  
ATTN: M. Cross

Institute for Defense Analyses  
ATTN: U. Signori  
ATTN: Classified Library

Kaman Sciences Corp.  
ATTN: W. Long

R & D Associates  
ATTN: R. Latter  
ATTN: R. Schaefer  
ATTN: R. Poll  
ATTN: Technical Information Center  
ATTN: P. Haas

R & D Associates  
ATTN: A. Cicolani  
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RCA Corp.  
ATTN: E. Van Keuren

SRI International  
ATTN: W. Jaye  
ATTN: C. Shoens

TRW Defense & Space Sys Group  
ATTN: W. Rowan

TRW Defense & Space Sys. Group  
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